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The MagPi

The official Raspberry Pi magazine | Issue 70 | June 2018 | raspberrypi.org/magpi

HOME AUTOMATION WITH RASPBERRY PI

Practical projects to take your home into the future

THE MAGNETIC MUSIC MACHINE

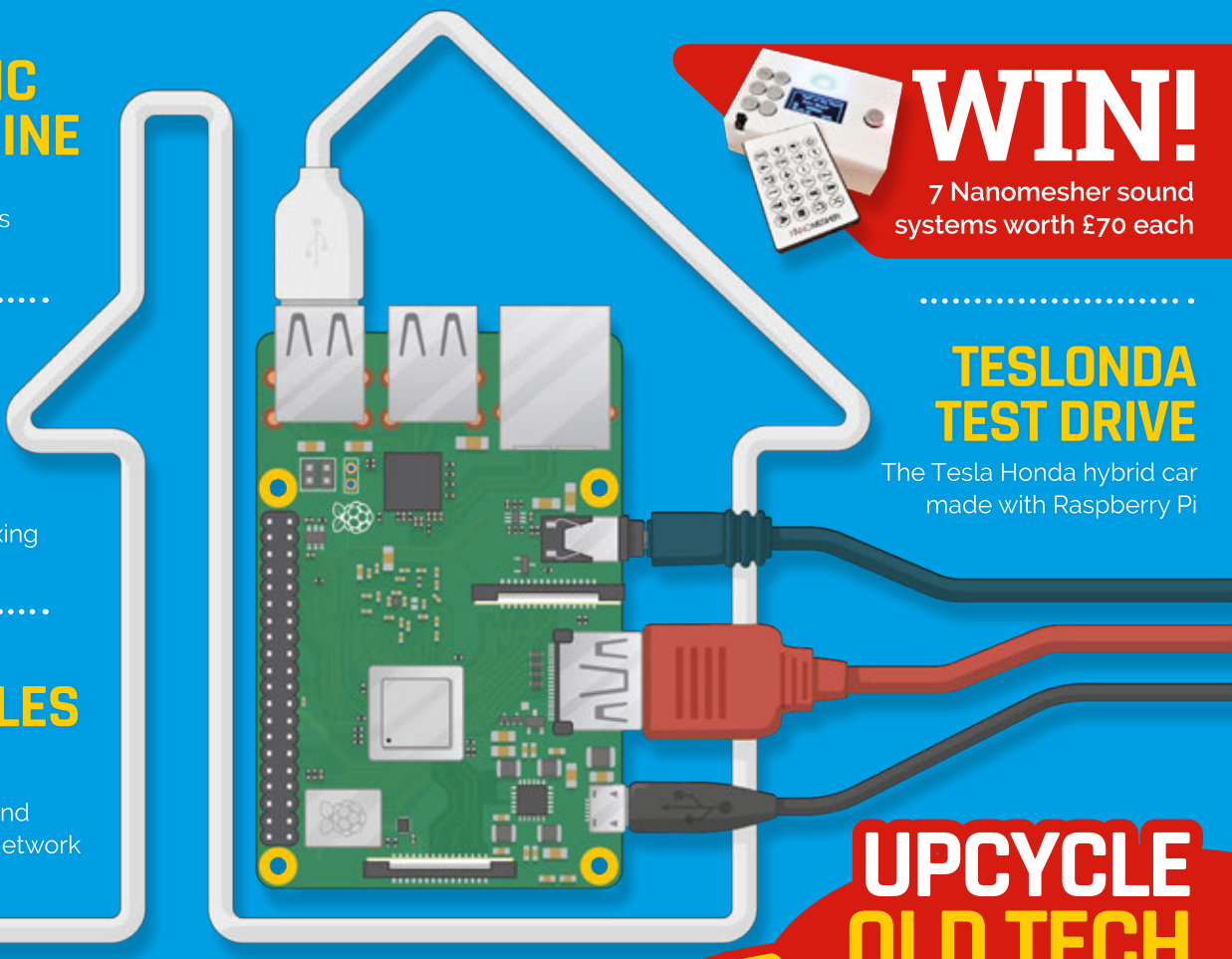
Build a theremin synth with a Raspberry Pi and magnets

MINECRAFT AND TMUX

Keep your Minecraft world safe with terminal multiplexing

TRANSFER FILES WIRELESSLY

Access your Raspberry Pi and transfer files over a home network



WIN!

7 Nanomesher sound systems worth £70 each

TESLONDA TEST DRIVE

The Tesla Honda hybrid car made with Raspberry Pi

UPCYCLE OLD TECH

Nothing goes to waste with our guide to tech recycling

Also inside:

- CREATE A TWEETING TEDDY BEAR WITH RASPBERRY PI
- IT'S HAPPY HOUR WITH THE RASPBERRY PI COCKTAIL MAKER
- THE KIDS ARE ALRIGHT WITH TODDLER'S ACTIVITY BOARD
- USE A THERMAL PRINTER TO BUILD A CHEAP POLAROID CAMERA

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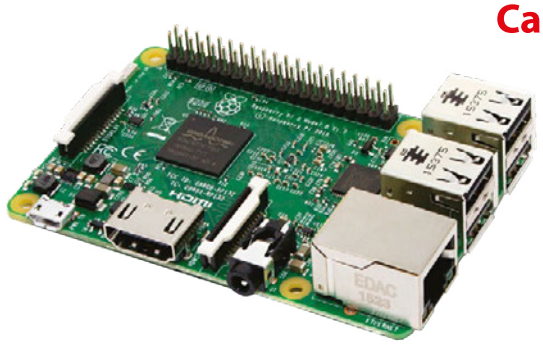

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MALE TO MALE & MALE TO FEMALE

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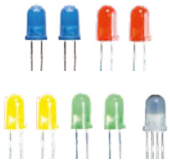

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WELCOME TO THE OFFICIAL MAGAZINE

It all started with a Tado. I won this quirky home thermostat in a competition, along with free setup. Since then, I've fitted smart lights, energy-measuring sockets, built my own internet doorbell, and – of course – set up a Raspberry Pi AIY Projects intelligent home speaker.

I love DIY. The only thing better than DIY is 'smart DIY', where you get the double satisfaction of a job-well-done that uses your tech skills.

Our Home Automation feature (page 16) has more information about installing stuff around the house than you'll ever need. From smart lighting and energy-monitored wall sockets, right up to automatic garage doors and temperature-controlled fish tanks.

Doing your own home automation isn't just more rewarding; it's also the smarter move. When you make your own home automation projects, you control the data they acquire and you know exactly what's going on in your system. Plus, you get to fix any faults without the expensive repair bills.

So don't just buy smart kit for your home that sucks up all your information; make it yourself and keep your home secure. That's what this issue is all about!

Lucy Hattersley
Editor

YOUR OFFICIAL RASPBERRY PI MAGAZINE
The MagPi
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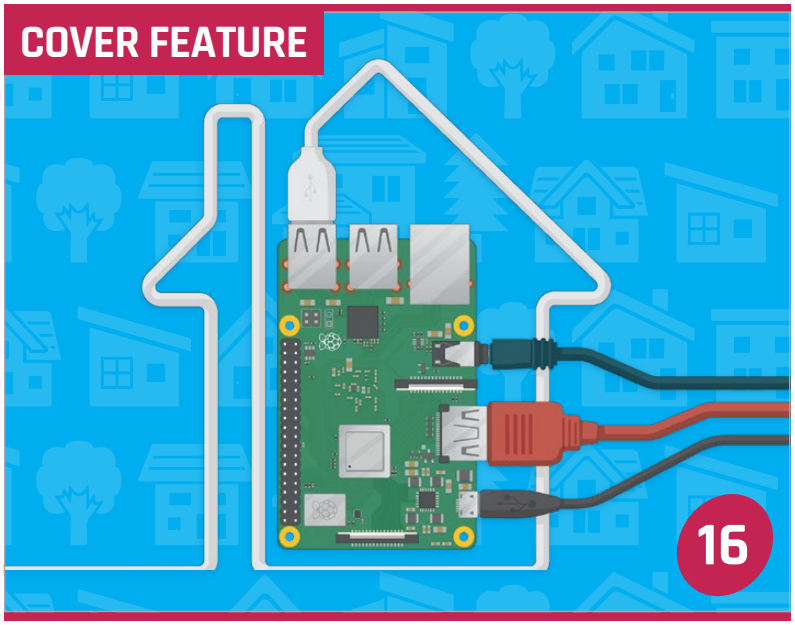

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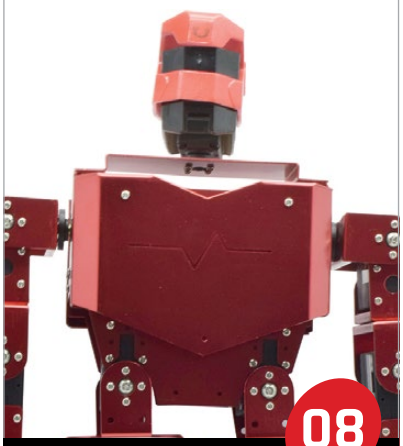

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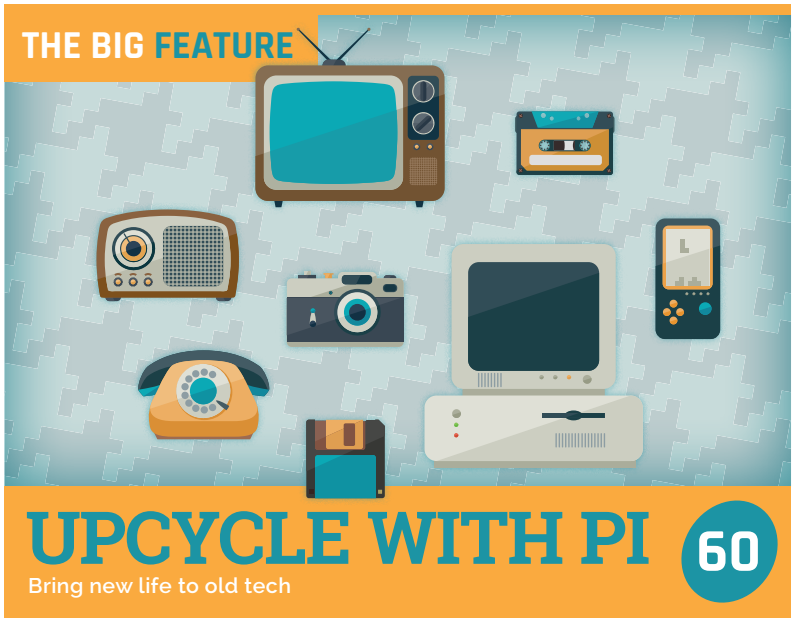

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UPCYCLE WITH PI

Bring new life to old tech

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WIN!

In association with NANOSOUND

7 NANOSOUND DAC PRO & AMP KITS

We've got seven NanoSound DAC Pro & Amp kits up for grabs

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Half Honda, half Tesla, all Pi-powered

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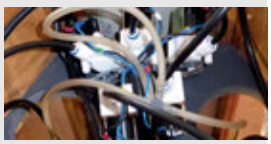

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RASPBERRY FIELDS FESTIVAL

A weekend to celebrate digital making

Join us for the first annual Raspberry Fields, a festival of digital making held over the weekend of 30 June and 1 July in Cambridge.

Organised by the Raspberry Pi Foundation, the weekend will be packed full of fun, exciting, thought-provoking and informative shows, projects, demonstrations, and talks.

For example, you'll be able to recreate your favourite potions and magical brews by visiting The Cauldron. These techno-wizards use molecular mixology and responsive 'magic' wands to create (non-alcoholic) cocktails, bringing "the magic from fantasy books to life". See **thecauldron.io** for a taster.

Elsewhere, drop in on the Museum in a Box, which shrinks entire "museum collections and expert knowledge" into a handheld box. You'll be able to experience some of the most exotic places on earth without moving a yard. See **museuminabox.org** for a preview.

For more inspiration, there will be a fantastic range of projects built by hobbyists just like you, using the Raspberry Pi, Arduino, micro:bit, and other technologies. If you're still in need of a creative kick-start, check out the quick-fire talks given by young makers from CoderDojos, Code Clubs, Raspberry Jams, and other groups.

Once you've got an idea for a project, you can browse the vendor stalls for that perfect bit of kit for your next build.

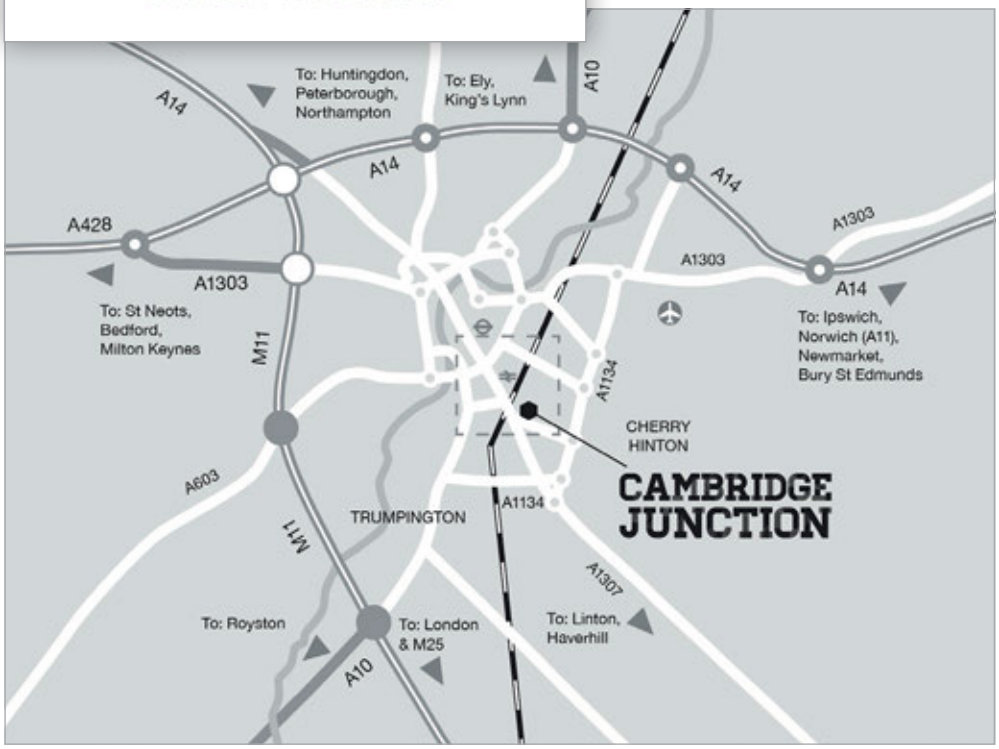

Image courtesy of Cambridge Junction, www.junction.co.uk

When we said we wanted 'quick-fire talks'...

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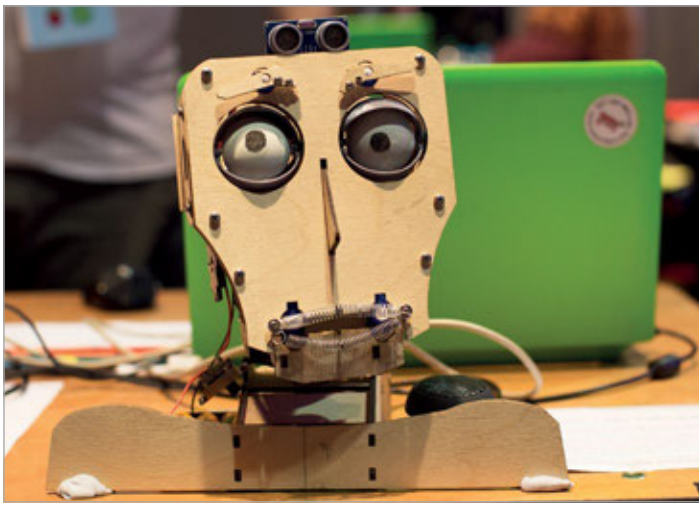


If all that sounds a little exhausting, you can see how fast your heart is beating in the Heart of Raspberry Pi chill-out zone. Here you'll be able to place your own heartbeat alongside hundreds of others in sealed jars that light up the room.

With many more shows, stalls, events, and acts still to be announced, Raspberry Fields is sure to be a brilliant and memorable day out, whichever day you attend. And of course there will be the obligatory face-painting, food, music, and generally loads of interactive fun to be had!

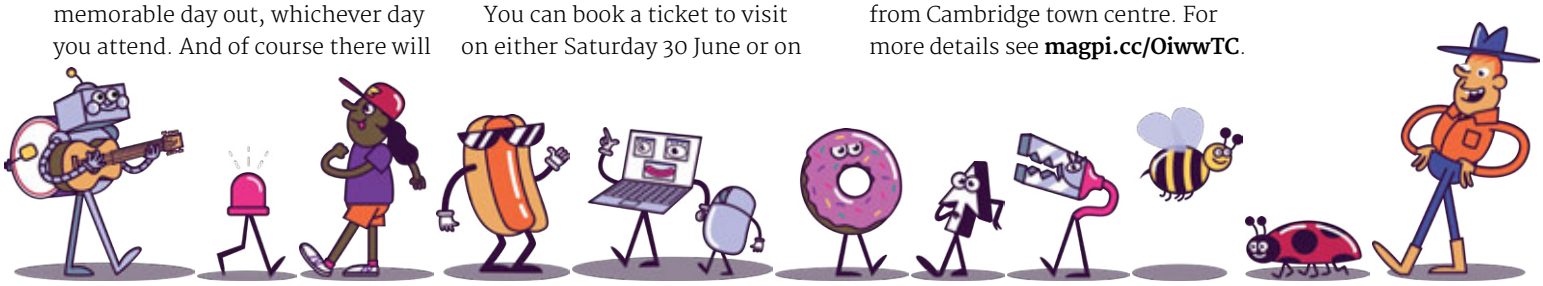
How to attend

You can book your tickets now, from the Cambridge Junction website: **magpi.cc/KxVqJc**. Tickets are free for under 16s, and £5 for everyone else. Every attendee will need a ticket, so please book now to avoid disappointment.

You can book a ticket to visit on either Saturday 30 June or on Sunday 31 July. The gates open at 10:30am on Saturday and at 10:00am on Sunday.

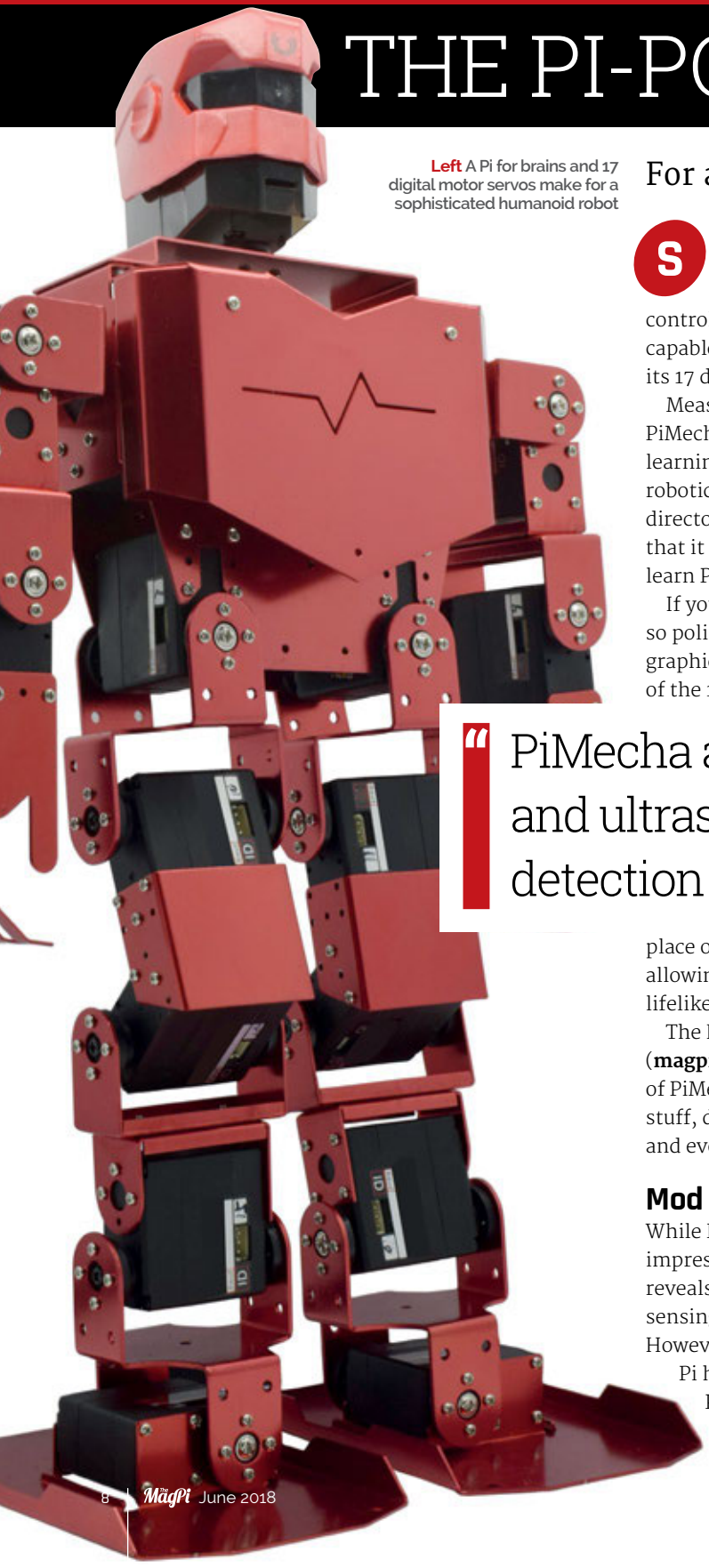
There are many easy ways to get to Cambridge Junction – it's less than ten minutes' walk from Cambridge railway station, and there's a secure car park at the neighbouring PureGym Cambridge Leisure Park if you're driving.

Locals can use the regular buses and the site is a 30-minute walk from Cambridge town centre. For more details see **magpi.cc/OiwwTC**.



PIMECHA

THE PI-POWERED ROBOT



Left A Pi for brains and 17 digital motor servos make for a sophisticated humanoid robot

For all your customisable robot needs

SB Components' latest creation is a fully customisable, fully controllable humanoid robot capable of natural motion via its 17 digital servo motors.

Measuring 370×448 mm (H×W), PiMecha "is designed to allow learning from basic to advanced robotics," says SB Components director Gajender Singh, adding that it "also enables students to learn Python programming."

If your Python skills aren't so polished, there's also a graphical control system. Each of the 17 servos is shown in place on a silhouette of PiMecha, allowing you to easily create very lifelike motions.

The Kickstarter page (**magpi.cc/nDQJbv**) shows videos of PiMecha strutting his funky stuff, doing press-ups, walking, and even turning cartwheels.

> "PiMecha also allows for connecting IR and ultrasonic detecting, for obstacle detection and distance measuring"

Mod my bot

While PiMecha's dancing is impressively smooth, Gajender reveals that "as of now, audio sensing is not enabled by us." However, "because the Raspberry Pi holds endless possibilities," PiMecha owners can add audio sensing "easily".

Some other potential upgrades are offered as part of Pledge bundles – the 4-inch LCD screen and Raspberry Pi Camera, for example.

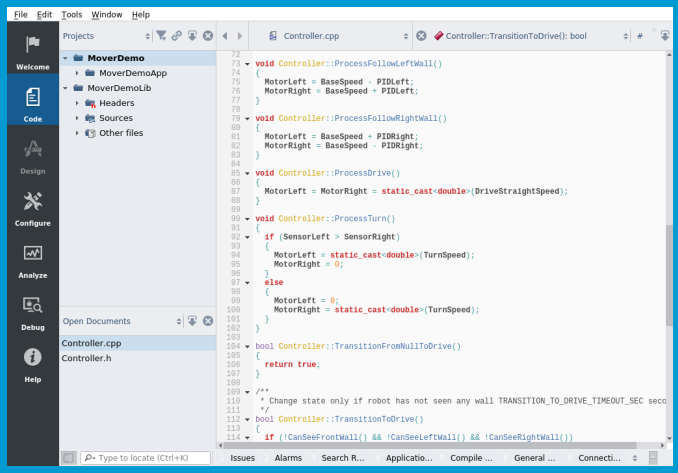
Upgrading PiMecha in other ways is also possible, as Gajender confirms that "PiMecha also allows for connecting IR and ultrasonic detecting, for obstacle detection and distance measuring respectively."

Agent of Shield

At the heart of the robot is the PiMecha Shield, governing not only the 17 servos but also managing the battery. Gajender reveals that you can connect the PiMecha Shield "either by using the GPIO stack [header] or by using the USB connection."

PiMecha's Kickstarter campaign is looking to raise a modest £25 000 by Sunday 17 June. The cheapest Pledge option is for an unassembled PiMecha with no Pi for £299; a pre-assembled PiMecha with a Pi 3B+ is listed at £339. PiMecha is compatible with most Raspberry Pi models, including the Pi Zero.

Should PiMecha achieve its funding goal, robots should start shipping in September 2018.



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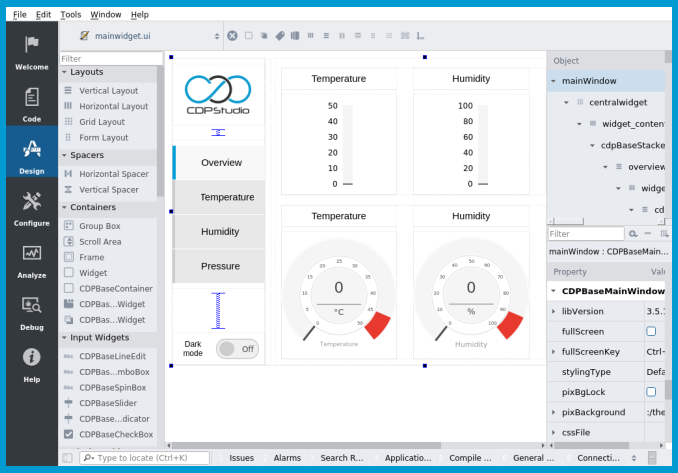

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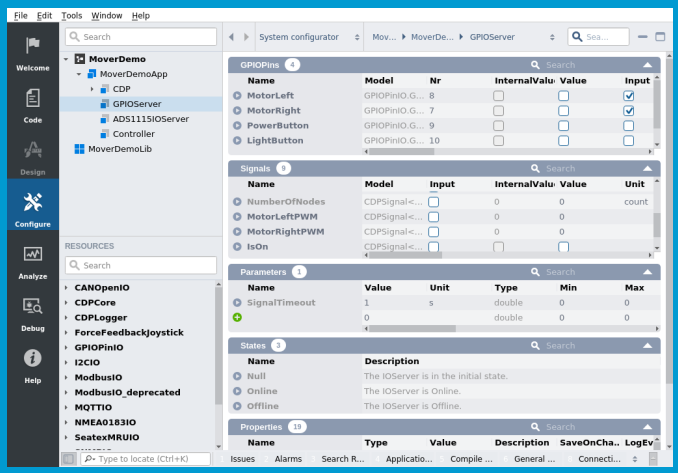

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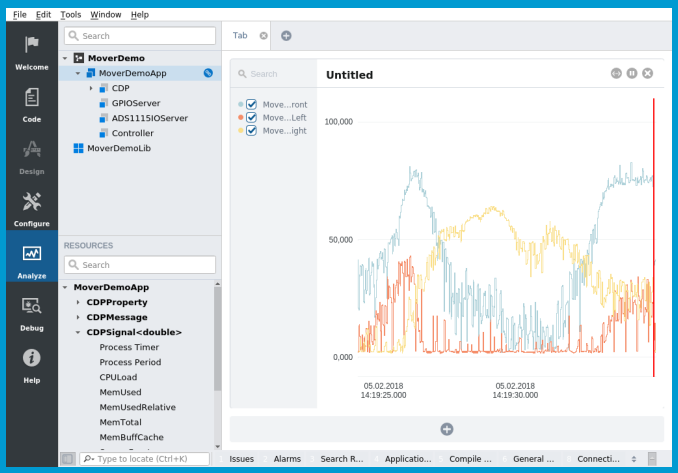

Analyze

Now free for home projects

A professional control system development tool

CDP Studio is a development platform for industrial control systems, now coming with a free version for non-commercial use. The system can run on a Raspberry Pi, supports C++, open source libraries and has a large feature toolbox including GPIO, I2C and MQTT. Its built in GUI design tool and features lets you code less and do more.

Free download on www.cdpstudio.com

CDP Technologies AS
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GOOGLE NSYNTH SUPER

AI instrument gets a body

Image courtesy of Google

Magenta, a Google research project to 'make music and art using machine learning', has collaborated with Google Creative Lab to create a musical instrument that uses AI to create entirely new sounds.

The project is a hardware implementation of the previously announced NSynth algorithm. This 'neural audio synthesis' algorithm doesn't blend different input sounds – instead it analyses the sonic characteristics of the sources to 'birth' an entirely new sound.

The NSynth Super takes the NSynth algorithm and implements it in an easy-to-use hardware form. Each of the four corner dials allows you to select one of four instruments, and then you can set the level of combination by dragging your finger across the touchscreen 'sound map'.

The custom PCB and bill of materials are open-source, as is the code, but assembly requires advanced soldering skills – see the GitHub page at **magpi.cc/kUvRKn** and Andrew Back's build guide for RS-Online at **magpi.cc/uNBJqG**. You can see the NSynth Super in action at **nsynthsuper.withgoogle.com**.

COOLEST PROJECTS UK

Hardware category winner Ayve demonstrates her creation: the Voice O'Tronik

First Coolest Projects show in UK "mind-blowing"

Coolest Projects UK was "the same level of mind-blowing" as any Coolest Projects International show, says Rosa Langhammer, CoderDojo's general manager, outreach and engagement.

Held on Saturday 28 April in London, the event "had over 40 projects," says Rosa, "presented with enthusiasm and confidence by each of the project presenters... In total we had over 500 people attend."

It's these presenters that make Coolest Projects events so special – they're CoderDojo Ninjas, aged 7–17, showing off their self-made projects.

Among some brilliant projects and presentations, Rosa particularly loved ten-year-old Ayve's 'Voice O'Tronik', which "responded to voice commands such as 'move arms' or 'roll eyes'."

Rosa was equally impressed by Ayve's "confidence and depth of knowledge" when presenting Voice O'Tronik, which was written in Python and uses the Google Cloud Speech API.

"Coolest Projects is absolutely not possible to run without project presenters (Ninjas), parents, and volunteers," Rosa acknowledges. "So to each and every person who contributed: thank you!"

Coolest Projects North America take place in Santa Ana, California on Sunday 23 September. Head to **magpi.cc/izcDmt** to register your project or book your ticket.

SDR WITHOUT THE SDR

All you need is a Raspberry Pi

Typically, software-defined radio (SDR) requires specific hardware, but a German research group from the Technische Universität Darmstadt has found a way to use just a Raspberry Pi 3B+.

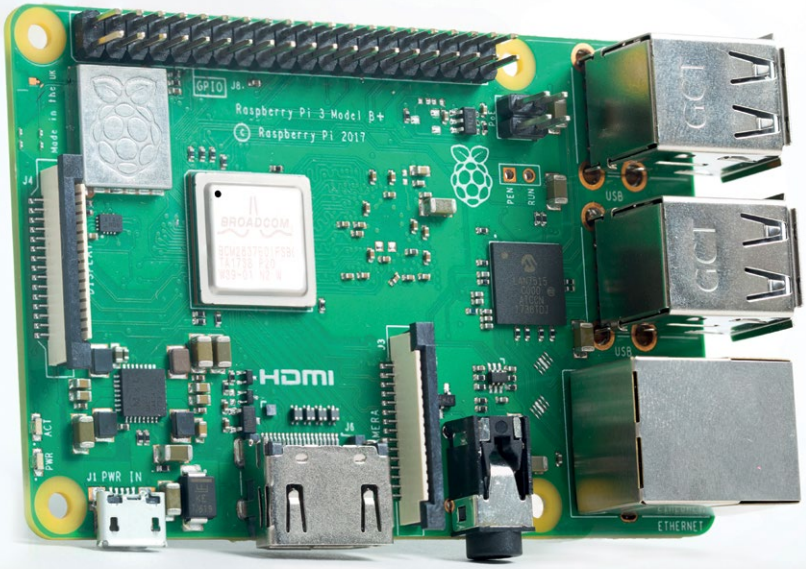
Matthias Schulz, Nexmon SDR project lead, tells us, "Broadcom 802.11ac WiFi chips can be turned into general-purpose SDRs and as soon as the Raspberry Pi 3 B+ was released, I was happy to find such a chip on such a widespread and cheap platform."

He says that the 2.4GHz band is the most interesting, as "there are many communication systems using this band, such as Bluetooth, ZigBee, remote-controlled toy cars, drones."

While Matthias admits that currently, the Nexmon SDR is a proof of concept requiring more development, "the WiFi chip should generally support both SDR-like signal transmissions and receptions."

The Nexmon SDR project is all open-source, and the code is on GitHub: **magpi.cc/MsDyJU**. Matthias reminds us that "the transmission of wireless signals is generally regulated," so ensure you have the correct licence "to build and operate custom wireless devices."

nexmon



Above Nexmon SDR doesn't need any extra hardware for software-defined radio, just a Raspberry Pi B3+

NOW TRENDING

The stories we shared that flew around the world

OPENCAT - A ROBOTICIST'S BEST FRIEND?

magpi.cc/mDwiYD

Chinese roboticist Rongzhong Li has created a robot cat, initially from modelling sticks and a Raspberry Pi beginner kit. The latest version is slightly more sophisticated, with voice commands handled by Alexa.

WEBOS COMES TO RASPBERRY PI

magpi.cc/JwocXK

A new version of the legendary Palm creation webOS has been launched for the Raspberry Pi. Aiming to be 'web-centric and usability-focused', the new webOS Open Source Edition is free to download and use.

SOFI THE ROBOT FISH

magpi.cc/sOzulD

Fortunately in no way related to OpenCat, SoFi has been developed by MIT researchers to study marine life up close, using its fish-eye lens and the internal Raspberry Pi 2.

SUSTAINABILITY COMPETITION WINNERS ANNOUNCED

PA Consulting's annual Raspberry Pi challenge roundup

Above The students from Ysgol Deganwy school receiving their £1000 prize for winning the Primary School Award category

The winners of PA Consulting Group's annual Raspberry Pi Competition were announced at the grand final in late April, with three schools each winning £1000.

This year's theme was sustainability: 'to invent something that will help save the planet'. With more than 100 schools applying, there was plenty for the judges – including the BBC's Rory Cellan-Jones – to consider.

PA Consulting's Raspberry Pi Competition co-ordinator John O'Neill explains that the projects "are aligned to curriculum activities, so they can help [students] achieve educational goals" as well as being "collaborative and fun".

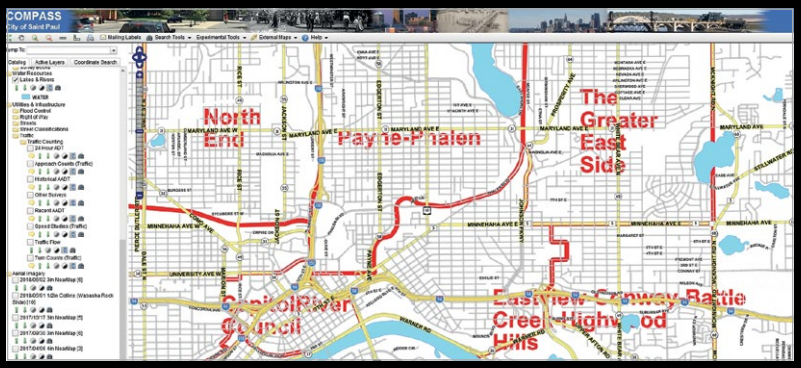
For example, students of Ysgol Deganwy school, Conwy, made 'Recycle Michael', which reads the barcode of a piece of rubbish and tells you which recycling bin to place it in.

John confirms that the judges "could imagine Recycle Michael being scaled up to appear in offices and home across the country."

Next year's Raspberry Pi Competition will be revealed in September 2018 – you can register your interest now at **magpi.cc/nZUmQe**.

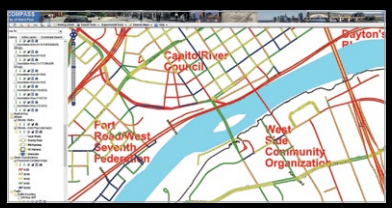
TOWN PLANNING ON A PI

Big data, small hardware



Above COMPASS is a sophisticated data visualisation tool that can run on a dash-mounted Raspberry Pi

COMPASS, the 'spatial data' system of the City of Saint Paul, Minnesota, might pull in "just under 3TB" of data from 32 live databases, but the system can run on a car-mounted Raspberry Pi 3.



At GITA 2018, GIS Systems Developer Bob Basques demonstrated how COMPASS overcomes the typical problems of old data or datasets too large to download in the field.

Bob tells us that using a Raspberry Pi allows field workers "to have similar access to the subset of data and tools they need for their job as they would in the office."

As COMPASS links to data sources, Bob clarifies that "any of them can break, and the interface just keeps chugging on."

Bob tells us that COMPASS is built on the GeoMoose open-source project (**geomoose.org**). Fellow GIS Systems Developer Jim Klassen adds, "We've been basically bucking the system for years with our open-source approach. The problem is, the stuff just keeps working."

The City of Saint Paul currently uses seven COMPASS-loaded Raspberry Pis. Try using the system yourself at **magpi.cc/IHOwGb**.

PI ZERO W WIRELESS ANTENNA

"DEMONSTRATES ENGINEERING EXPERTISE"

Independent RF engineer tests wireless Pi performance

Radio frequency engineer Carl Turner decided to test the Raspberry Pi Zero W's wireless performance, and we're pretty sure he was impressed by the tiny antenna's design.

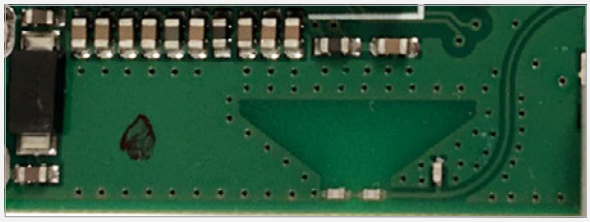
Carl tells us, "There was a lot of buzz about the new antenna. With its small size, and unique design, I was curious about how well it performed." As senior RF Engineer at Laird Technologies, Carl decided to use Laird's antenna test chamber to test the Pi Zero W's wireless antenna.

Carl wrote up his findings on Embedded Computing Design (**magpi.cc/MsYQZP**), noting that while he had his doubts about such a small antenna, "overall, I am impressed with the quality of the radiation pattern."

Comparing the Pi Zero W's tiny antenna with that of a WiFi router, Carl found that "the Zero W only concedes 2.25 dB of antenna efficiency while reducing the maximum antenna dimension by 8×."

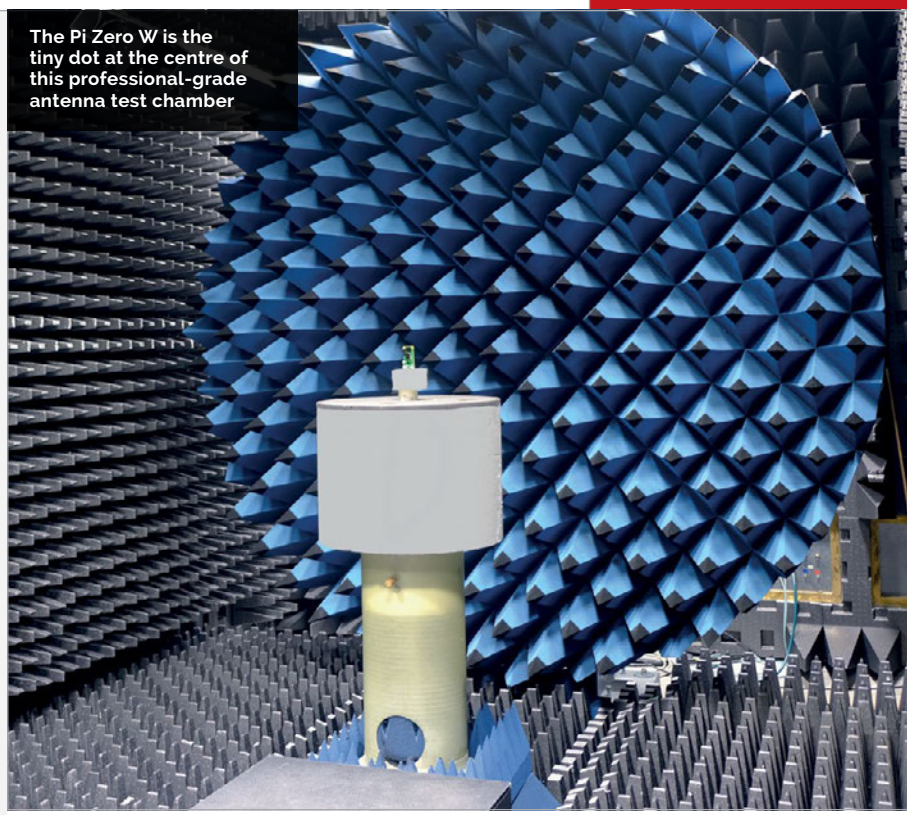
It's a trap-ezoid!

Carl doesn't attribute the surprising performance to the trapezoidal shape of the Pi Zero W's antenna, as while "interesting... the shape of the antenna by itself is somewhat irrelevant." Instead, he praises "that the sleek custom design efficiently fits the limited space", which "demonstrates the engineering expertise and design effort" that allows the antenna to perform well.



Above A close-up of the Pi Zero W's "interesting" trapezoidal wireless antenna

Images courtesy of Jason Olson, Laird Technologies



The Pi Zero W is the tiny dot at the centre of this professional-grade antenna test chamber

DEXTER INDUSTRIES

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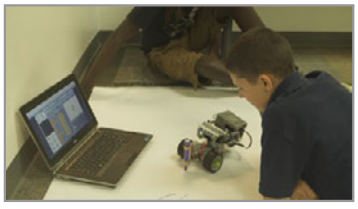
20+ new projects for your Pi robot car.

BrickPi3

LEGO MINDSTORMS + RASPBERRY PI



www.dexterindustries.com

pi-top

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pi-top

Colors

Raspberry Pi 3 optional

AWESOME INVENTOR'S KIT INCLUDED

20+ projects to explore

Explore beyond the screen and keyboard by creating with the all-new **pi-top** modular laptop.

Get started with 20+ inventions in the inventor's guide booklet. There are 3 inventor's journeys - Smart Robot, Music Maker and Space Race.

The modular desktop

14" FULL HD 1080P SCREEN

MODULAR RAIL

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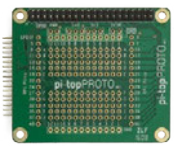
pi-topCEED

Colors

Raspberry Pi 3 optional

pi-topCEED is the plug & play modular desktop. It's the easiest way to use your Raspberry Pi. We've put what you love about our flagship laptop in a slimmer form factor. Join hundreds of code clubs and classrooms using **pi-top**CEED as their solution to Computer Science and STEAM-based learning.



pi-topPROTO

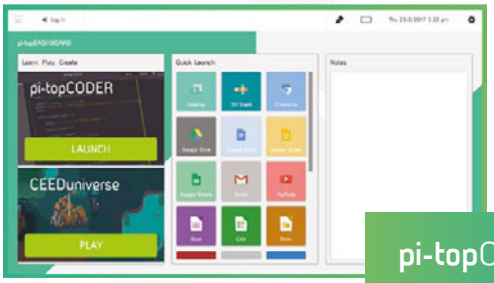
pi-topSPEAKER

pi-topPULSE

Modular **Accessories**

pi-top is an award-winning ecosystem designed to make experimenting, coding and building electronics, simple, affordable and fun. **pi-top**OS is here to guide you through the world of making!

The OCR* endorsed **pi-top**OS (Operating system) platform comes pre-installed on the SD card shipped with every unit. **pi-top**OS software suite lets you - browse the web, - check emails, - create and edit Microsoft Office compatible files. Gain access to dozens of hands-on learning lesson plans with **pi-top**CODER and have fun learning to code with CEED**universe**!



pi-topOS

pi-topCODER has a fully integrated coding environment letting you program hardware, code in Python and learn lots of STEAM skills! Our integrated test framework gives you the ability to assess your own understanding as you learn.

CEED**universe**

Learn programming concepts through our minigames, for example, learn problem decomposition by solving visual programming puzzles.

HOME AUTOMATION WITH RASPBERRY PI

Practical projects that take your home into the future

The Raspberry Pi is an ideal match for home automation projects. It's got a small footprint, has GPIO pins for input and output, and you can code it yourself.

There's also a huge range of ideas, projects, and products designed to help you automate your home. Home automation is one of the most popular project areas and new ideas crop up on a daily basis.

> Armed with a Raspberry Pi, and a good idea, you can transform everyday items

All of this makes home automation one of the most exciting areas of Raspberry Pi. We all want to live in the home of the future, where things get done for us smartly and quickly by computers.

In this feature we look at all the different options available to you, from home sockets, through to controlling lights, doors, and doorbells. We look at installing smart CCTV systems with automatic face detection, as well as automating the sensing and controlling of temperature.

Armed with a Raspberry Pi, and a good idea, you can transform everyday items around the house into smart internet-connected gizmos.

BUTTON PUSHERS

Write code that presses any button in your home with these nifty button pushers

DOORS AND DOORBELLS

Use switches with a Raspberry Pi to turn standard doors and doorbells into smart devices. These can send alerts to your mobile phone when a door is opened (or doorbell pushed)

INTELLIGENT CAT FLAPS

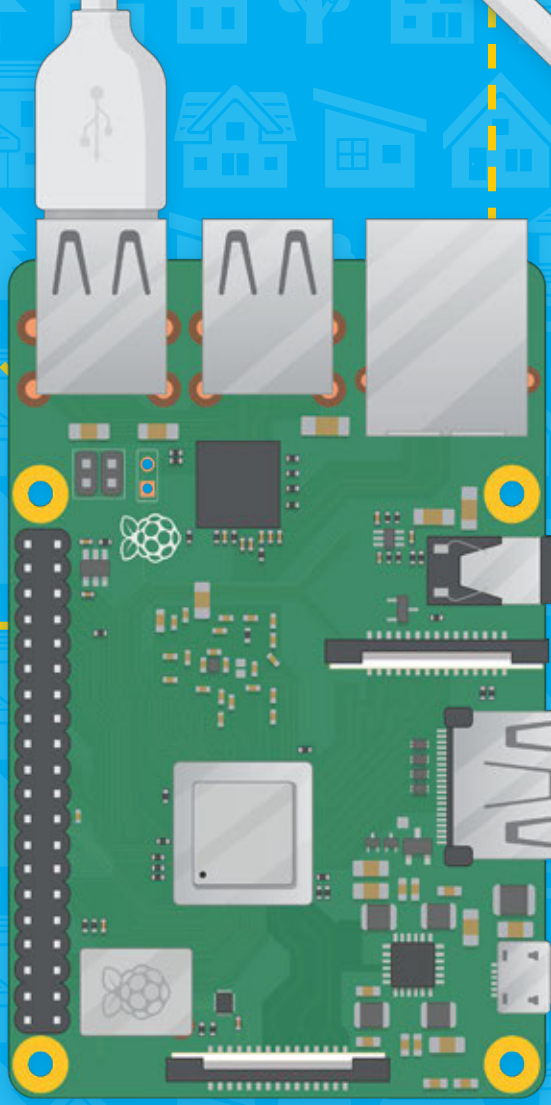
Make life easier for your kitty by building a smart face-detection cat flap. It's a good way to experiment with face detection and door opening

POWER SOCKETS

Adding code-controlled power sockets around the home enables you to turn devices on (or off) and measure energy usage

SMART CCTV

Security cameras are much more intelligent when you use Raspberry Pi face detection



PJ EVANS

PJ runs the Milton Keynes Raspberry Jam at The National Museum of Computing, where he also volunteers. His garage door has an API.

mrpjevans.com

CONTROL POWER SOCKETS WITH PYTHON

With Energenie's remote-controlled sockets and Pi-mote, switching a mains appliance on and off with a Raspberry Pi has never been easier

Controlling mains devices with a Raspberry Pi can be surprisingly tricky. You really don't want to get involved with mains electricity unless you know what you're doing, and internet-connected sockets are locked down to their own apps, deterring the wily hacker. Energenie's Pi-motes provide a simple and elegant solution, allowing control of Energenie radio-controlled sockets using a simple add-on that fits straight on to the Pi's GPIO header. A few lines of Python later and you're safely and easily commanding your home appliances.

What makes Energenie's range of home automation gizmos interesting is their affordability, and the embracing of the Raspberry Pi community. The Pi-mote range allows control of Energenie's sockets and more from any Raspberry Pi.

For this tutorial we're going to be using the second-generation Pi-mote which allows for two-way communication and control of more devices. Although we're only going to be sending data, it may be well worth getting this version of the Pi-mote for future-proofing your projects. The following instructions are not suited to the original Pi-mote.

POWER UP

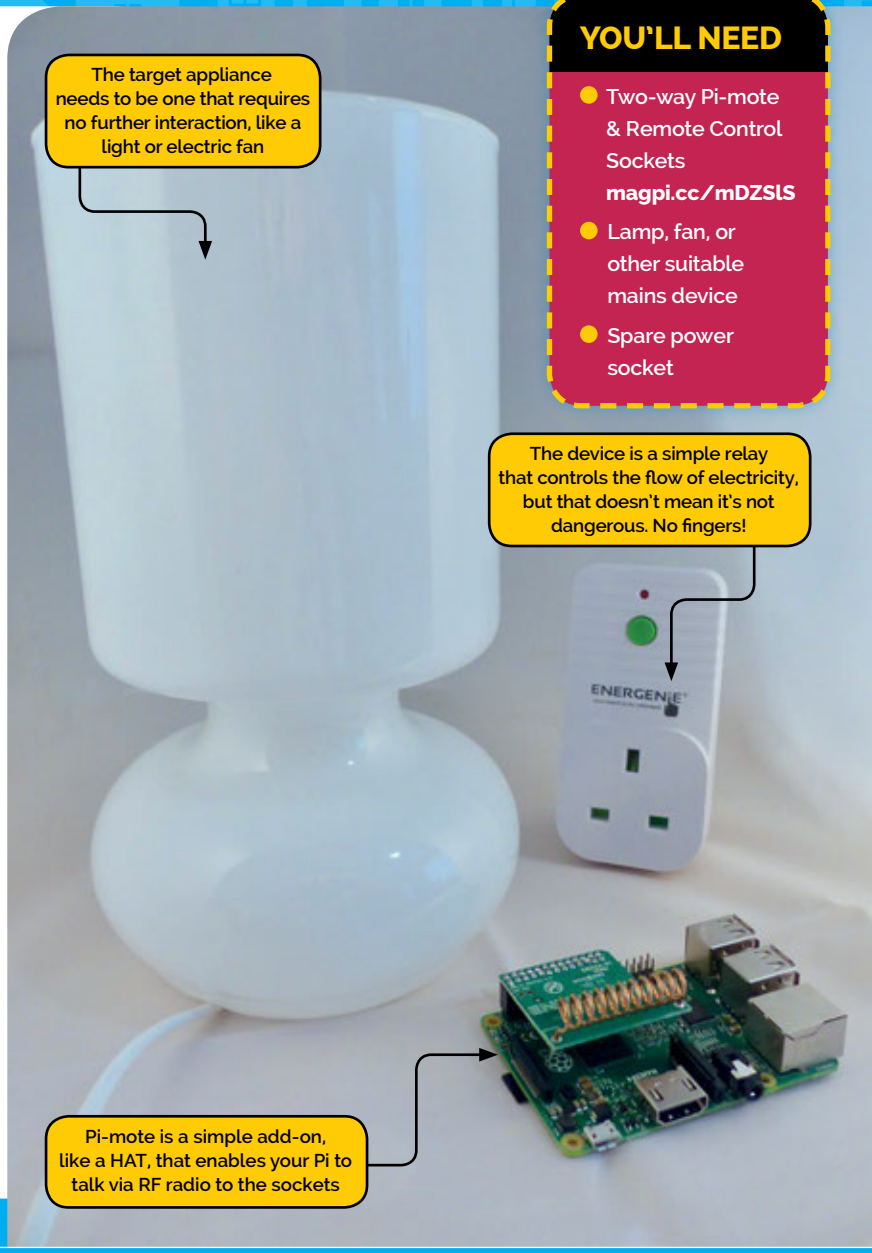
First of all, get your Energenie device and plug it into something interesting. We recommend a power socket for maximum effect. Other things, such as custard, may yield disappointing results. Now plug your mains device of choice into the remote-control socket, such as a lamp or fan.

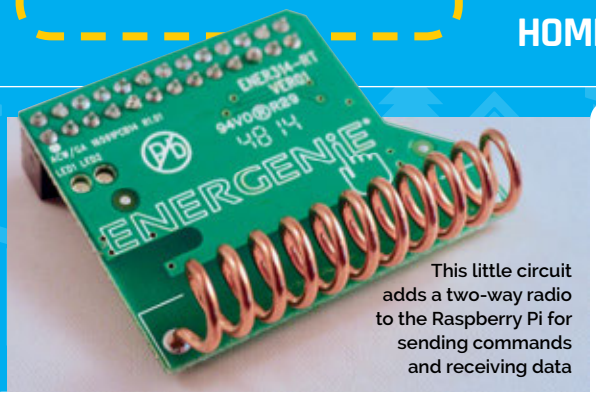
CHOOSE THE RIGHT DEVICE

Only certain appliances work well with these sockets. A TV will just go into standby mode, but an LED light strip is perfect.

YOU'LL NEED

- Two-way Pi-mote & Remote Control Sockets **magpi.cc/mDZSlS**
- Lamp, fan, or other suitable mains device
- Spare power socket


The target appliance needs to be one that requires no further interaction, like a light or electric fan
The device is a simple relay that controls the flow of electricity, but that doesn't mean it's not dangerous. No fingers!
ENERGENIE
Pi-mote is a simple add-on, like a HAT, that enables your Pi to talk via RF radio to the sockets



This little circuit adds a two-way radio to the Raspberry Pi for sending commands and receiving data

One of the great things about home automation is that it rarely requires any significant horsepower from the processor, so these are great projects for any older Raspberry Pi devices you have lying around and are especially suited to the Zero W. Everything will work with your overclocked 3B+, but it may be overkill.

PLUG IN

The Pi-mote connects like a HAT, but only has 26 connectors, so it's important to attach it correctly. (Bonus: this means it's compatible with the first generation of Pi boards.) Line up the Pi-mote so the antenna runs parallel with the GPIO header, with the Pi-mote covering the main Pi board, and connect to the first 26 pins of the GPIO. Now get yourself to a command line and we're ready to go.

Although the Pi-mote uses SPI to communicate with your Pi, the software does not use the hardware implementation. If you have previously enabled SPI, disable it now using raspi-config. If you are working from a clean image or haven't the faintest idea what we're talking about, carry on.

Although Energenie has official software for Python, it is based on a project by David Whale who has been making constant improvements, so we're going to be brave and use his code.

We'll use Git to download the latest version. If Git is not already installed, run the following command:

```
sudo apt install git
```

Now let's download the code to your home directory:

```
cd
git clone https://github.com/whaleygeek/
pyenergenie
```

SWITCH ON

Place the socket into learning mode by pressing and holding the green button for five seconds until it starts to flash. Now run:

```
sudo python ~/pyenergenie/src/setup_tool.py
```

Select 'Legacy Learn Mode' from the main menu. When prompted for the house code, press **ENTER**, then **1** for the device index. As soon as you press **ENTER** again, your lamp/fan/powered-hamster-wheel should spring to life and then turn off again. **CTRL+C** will bring you back to the menu; pressing it again will quit the program. Your socket is now trained to be device 1.

To use the socket in your own apps, there is a gotcha. The 'energenie' Python library and the support in gpiozero are for the older board and will not work here. Instead, reference the energenie library used by the code you've just downloaded. It lives in **~/pyenergenie/src/energenie**. To get you started, create a new file in **~/pyenergenie/src/** called **testlight.py** and add the following code:

```
import energenie, time
energenie.init()
device = energenie.Devices.MIHO008((None, 1))
device.turn_on()
time.sleep(1)
device.turn_off()
energenie.finished()
```

Save and run as follows:

```
sudo python ~/pyenergenie/src/testlight.py
```

Your light should switch on then off. Now you have the building blocks for your own cool automation projects.

GET THE RIGHT LIBRARY

There are two versions of the Pi-mote. Use gpiozero to control the original one-way device.

WATCHING THE ELECTRONS

We've looked at controlling sockets in the tutorial, but our Pi-mote is a two-way device. Energenie also offers remote-control sockets that relay usage information back to the Raspberry Pi. With a little code, you can start monitoring electrical usage around the home.

Many electricity suppliers offer monitoring solutions, such as the CurrentCost range of products (**currentcost.com**). These combine a home display with a Bluetooth-connected sensor attached around the main feed to the meter. With a bit of tinkering, you can hook the receiver's data stream to a Raspberry Pi and get consumption data for the entire house, all without going anywhere near the actual supply (**magpi.cc/UmBiUE**).

If you're really serious or need some industrial-grade kit, OpenEnergyMonitor (**openenergymonitor.org**) has you covered. It provides a range of professional devices that monitor power, solar PV, heat pumps, and more.

Although many other projects exist, some involve a form of direct connection to the mains supply. Unless you're a qualified electrician, we would not recommend these. Try to keep all your personal electrons in roughly the same place.

MONITOR DOORS AND DOORBELLS

Detecting doors opening and doorbells ringing are building blocks for a lot of fun

Adding sensors to household items like doors and doorbells is straightforward and safe. Once the sensor is triggered, the resulting actions are only limited by your imagination. Want a door opening to switch on a lamp, trigger the washing machine, and send a text message to the cat? Go for it!

Anything that opens and closes can be easily detected using inexpensive home-security reed switches. Connecting these switches to a Raspberry Pi is about as simple as it can be. Doorbells are a little more tricky, but there are a few options we can explore.

We're often a bit absent-minded about leaving the garage door open. Your humble writer also uses noise-cancelling headphones, and regularly leaps out of the seat as someone taps him on the shoulder. The solution is to monitor both doors.

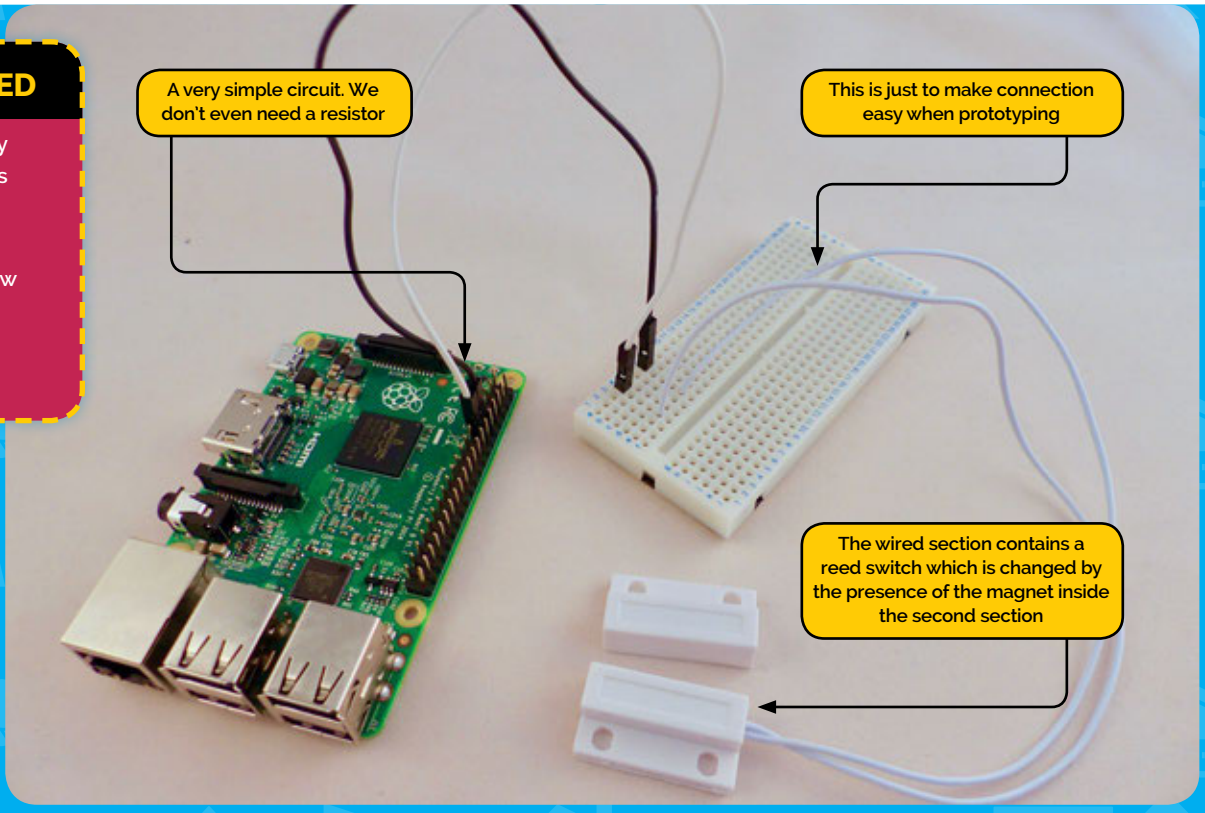
Detecting the opening of any kind of door is made easy using security reed switches. These are commonly found as part of alarm systems. Best of all, they are very cheap. You will have two parts, one wired and one not. The unwired part is a simple magnet. This should be connected to the window itself rather than the frame; that's where the wired part goes. Inside is a simple reed contact switch. Normally the switch is open, so no electricity flows through. When the magnet comes close (typically within a few centimetres), the switch closes. So, the switch opening equals the door or window being opened. You can now react as you please.

> "Detecting the opening of any kind of door is made easy using security reed switches"

Such is the elegant nature of this project that we don't even need a physical circuit to monitor these

YOU'LL NEED

- Wired Security Reed Switches **magpi.cc/cdqwOm**
- Door or window (or anything that opens)
- Doorbell


A very simple circuit. We don't even need a resistor
This is just to make connection easy when prototyping
The wired section contains a reed switch which is changed by the presence of the magnet inside the second section

types of switches – we can connect them directly to the GPIO. That said, don't go around sticking sensors to all your door frames just yet; let's prototype first.

Off-the-shelf security reed switches typically come with bare wire endings and are quite short, so you may need to extend them. Use a breadboard or solder on some connectors to make it suitable for connection to the GPIO. We found some spare jumper-jerkies and soldered the wires together for testing, but used a 3.5 mm stereo plug and socket for the final project.

Our switches are not polarity-sensitive, so choose one wire and connect it to any ground (GND) pin of the GPIO. Connect the second wire to GPIO17 (physical pin 11). Why 17? Why not? You can use any available switchable GPIO pin you wish.

Now, in your favourite code editor, create **door.py** and add the code from the listing.

The script expects the door to be closed when starting, so place the magnet alongside the switch and start the script.

```
python door.py
```

Move the magnet away from the switch. If all is well, 'Open' will appear on the screen. Move it back and you'll see 'Closed'.

door.py

LANGUAGE: Python 3

DOWNLOAD: magpi.cc/BedKSL

```
import RPi.GPIO as GPIO, time

# Use Pin 11 (GPIO17)
GPIO.setmode(GPIO.BCM)
GPIO.setup(17, GPIO.IN, pull_up_down=GPIO.PUD_UP)

# Default door state
isDoorOpen = False

# What was the previous state? (For detecting a change)
lastDoorState = False

# Loop forever
print("Monitoring")
while True:

    # False if the door is closed
    isDoorOpen = GPIO.input(17)

    # Has there been a change in the door state?
    if(isDoorOpen != lastDoorState):

        lastDoorState = isDoorOpen

        if(isDoorOpen == True):
            print("Open")
        else:
            print("Closed")

    # Wait a second before polling again
    time.sleep(1)
```

MONITOR ALL THE THINGS

You now have everything you need to detect anything that can open inside a frame. What you do next is up to you. For the garage door, our code waits until it has been open for over five minutes and then uses Pushover (an email-to-mobile alerting service for iOS and Android) to deliver alerts. For the office, the immediate opening of the door triggers an LED light on our desk, hooked up to a different GPIO port.

DING, DONG!

To incorporate doorbells into your project, use a simple switch like the reed switches. Pressing the doorbell will cause the GPIO input to report 'false' (as we are using pull-up resistors) and you can react as you wish. If you have a wired-in doorbell and want to detect whether someone is at the door, you can also piggyback onto the existing circuit, but check what kind of voltages are in use as you might fry your Pi. Alternatively, wireless door chimes can be easily and safely hacked to detect activation, meaning you can put the Raspberry Pi wherever you wish within range.

BUILD A SMART CCTV SYSTEM

Ever since the launch of the Pi Camera Module and PiNoIR, the Raspberry Pi has seen its fair share of camera projects. With their diminutive size, low cost, and frugal power requirements, Raspberry Pi devices are the perfect candidates for home security camera projects. Whether it's pet cams, baby monitoring, wildlife or good old-fashioned security, there's something out there for you.

As well as many 3D-printable cases, there's a wide range of professionally made options to ensure watertight operation and even standard cases like the official Pi Zero case offer a housing for the Pi Camera Module. It's also straightforward to take a standard CCTV housing and adapt it to the Raspberry Pi, as there tends to be lots of space.

For software you're spoilt for choice. Simple time-lapse recording can be done from the command line, and more complex operations can be provided by dedicated operating systems such as motionEyeOS. For the more advanced user, image-recognition packages such as OpenCV have a steep learning curve but offer a level of technology and AI not seen in off-the-shelf CCTV packages.

Here are three online examples that may interest you:

- How I set up a CCTV camera with Raspberry Pi Zero W and motionEyeOS image for home surveillance – **magpi.cc/hhutzr**
- Smart Security Camera: CCTV with OpenCV Face Detection – **magpi.cc/YweRuh**
- Multiple security camera setup using Raspberry Pi – **magpi.cc/HEjuIL**

MAKE A SMART FISH TANK

The sensor can live within the filtration system, but make sure the Raspberry Pi doesn't get wet!

Adding a temperature sensor and a Raspberry Pi to your tropical tank could save fishy lives

CHECK OUT: PROJECT THINGS

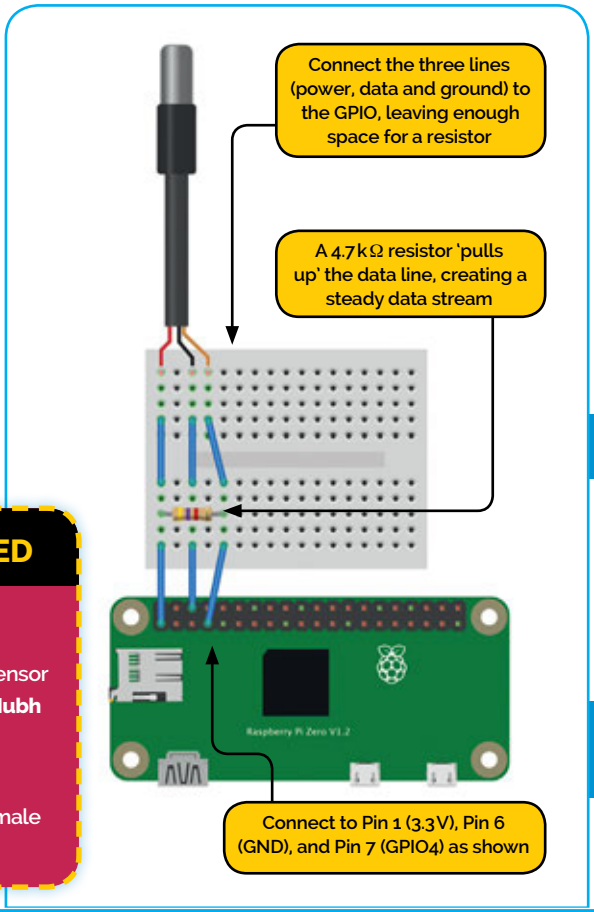
This newly released OS transforms the Pi into an Internet of Things gateway capable of controlling a wide range of devices, including wireless lights (requires USB add-on). It also provides an infrastructure for devices to communicate with each other over the internet.
iot.mozilla.org

YOU'LL NEED

- DS18B20 waterproof temperature sensor **magpi.cc/xdHubh**
- 4.7kΩ resistor
- Breadboard
- 3 × male-to-female jumper jerkies

Part of the fun of home automation is taking something that you wouldn't normally associate with the internet, such as a coffee machine, toaster or Great Aunt Hilda, and making it better. There's plenty of opportunity to add in sensors all over the house.

The sensor used in this project is amazingly accurate and very inexpensive – ours was less than £2. It uses the 1-Wire data protocol, which is well supported by Python.


Connect the three lines (power, data and ground) to the GPIO, leaving enough space for a resistor
A 4.7kΩ resistor 'pulls up' the data line, creating a steady data stream
Connect to Pin 1 (3.3V), Pin 6 (GND), and Pin 7 (GPIO4) as shown

Our project will take regular temperature readings with the ability to raise alerts as required. The sensor works just as well out of water, so can be used for any environmental monitoring purpose. Please note, although waterproof, it is not suitable for a marine (i.e. saltwater) tank.

> "The sensor used in this project is amazingly accurate"

The data line requires a pull-up resistor to work correctly, so let's build a simple circuit (see left). The wire screening of the sensor does not need to be connected, just the three wires: power, ground, and data.

WIRE UP 1-WIRE

Support for 1-Wire now needs to be enabled in Raspbian. We can use the raspi-config app to do this.

```
sudo raspi-config
```

Select Interfacing Options, then 1-Wire, then Enable. You can now exit. There's no need to reboot.

Each sensor has a unique device ID and we need to discover ours to check it's working. First, let's tell the operating system that we're going to be using 1-Wire and in particular the thermistor.

```
sudo modprobe w1-gpio
sudo modprobe w1-therm
```

You should not see any response from these commands. That's no problem.

```
cd /sys/bus/w1/devices/
ls
```

You'll see a directory that starts with '28-'; that's our device. Change directory (tip: type in **cd 28-** then hit **TAB** to fill out the rest) and enter the following:

```
cat w1_slave
```

Press **ENTER** and check the output. Look at the second line; the last part will start 't='. The following number is the current temperature × 1000, the maximum accuracy.

```
79 01 ff ff 7f ff ff ff 2a : crc=2a YES
79 01 ff ff 7f ff ff ff 2a t=23562
```

In this example, the temperature is 23.562°C.

A SNAKE IN THE TANK?

To use Python with the sensor, we need to install a library written by Timo Furrer:

```
sudo apt-get install python-w1thermsensor
```

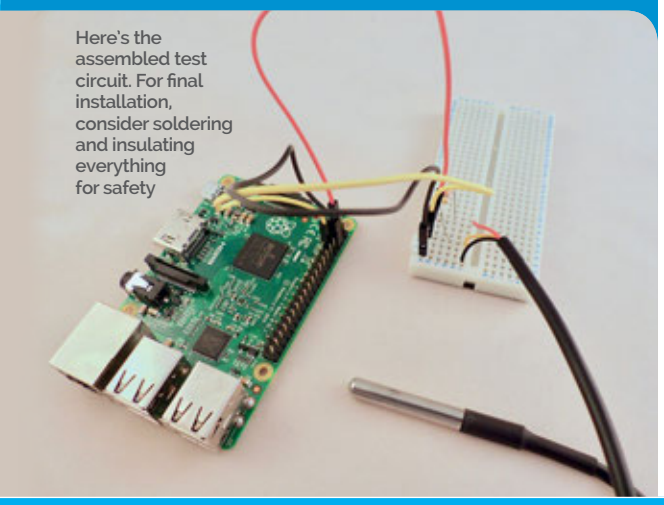
Create a file called **temp.py** and add the following:

```
from w1thermsensor import W1ThermSensor

sensor = W1ThermSensor()
temperature_in_celsius = sensor.get_
temperature()

temperature_in_fahrenheit = sensor.get_
temperature(W1ThermSensor.DEGREES_F)
temperature_in_all_units = sensor.get_
temperatures([
    W1ThermSensor.DEGREES_C,
    W1ThermSensor.DEGREES_F,
    W1ThermSensor.KELVIN])

print(temperature_in_celsius)
```



Here's the assembled test circuit. For final installation, consider soldering and insulating everything for safety

Note: So the 1-Wire modules load automatically, any Python code using W1ThermSensor must be run as root by using sudo.

```
sudo python temp.py
```

THE GOLDILOCKS LOOP

Now we can create a temperature monitor that checks every 15 minutes. A tropical aquarium needs to remain between 21°C and 27°C to avoid the fish taking strike action.

```
from w1thermsensor import W1ThermSensor
from time import sleep

sensor = W1ThermSensor()
upperThreshold = 27
lowerThreshold = 21

while(True):
  temperature = sensor.get_temperature()
  print('Current temperature: ' +
str(temperature))
  if (temperature > upperThreshold ):
    print('Too hot')
  elif (temperature < lowerThreshold ):
    print('Too cold')
  else:
    print('Just right')
  sleep(900)
```

When it is too hot or too cold, you can add code to trigger alerts such as emails and SMS messages using services such as Twillio, or even make a sound or illuminate a sign.

As it turned out, after a few months of running this code, the new heater failed as well. This time we were alerted as soon as the temperature went out of range. Unfortunately, we were on holiday at the time so had to contact a neighbour to ask them to go to our house and switch off the offending device. So, to complete the loop, we've added an Energenie remote control socket:

```
if (temperature > upperThreshold):
    print('Too hot')
    # Shut down the heater
    energenie.init()
    device = energenie.Devices.
MIHO008((None, 1))
    device.turn_off()
    energenie.finished()
```

Now, when the temperature goes out of range, the fish are instantly saved from an unwelcome spa day. Keep an eye on the tank at **mrpjevans.com/fish**.

CHECK OUT: ANDROID THINGS

Build professional-grade IoT controllers and devices using the Android OS. A development package is now available for the Raspberry Pi. The website features a wealth of information on making your own IoT devices.

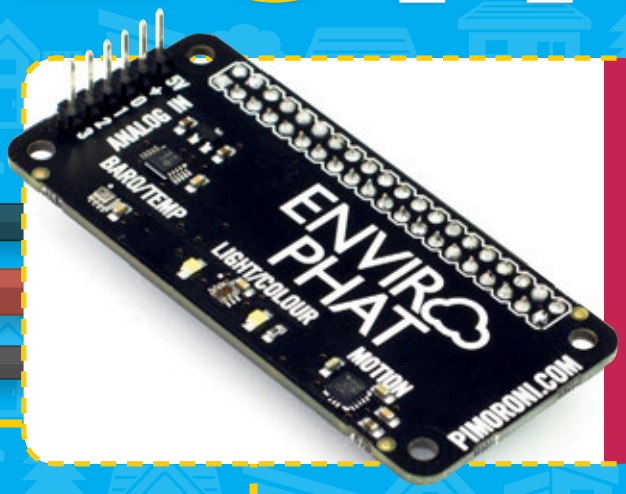
magpi.cc/qzgbkU

CHECK OUT: WINDOWS 10 IOT CORE

This slimmed-down version of Windows 10 is optimised for ARM processors and is designed for building commercial IoT devices. As well a host of tools for IoT development, some interesting Windows technologies such as Cortana are also included. Take a look at *The MagPi* issue #48 (**magpi.cc/48**).

magpi.cc/fcLsNm

10 DIGITAL HOME PROJECTS



BE ENVIRONMENTALLY FRIENDLY

The Enviro pHat from Pimoroni is an all-singing, all-dancing collection of sensors measuring temperature, pressure, light colour, and motion. It even has analogue inputs. Specially sized for the Pi Zero, it's ideal for monitoring projects in small spaces.

magpi.cc/AZrQwO

THE TEA-TIME KLAXON

Your writer has a teenager. It likes to sit in its room with headphones studying (read: gaming) for long periods of time. Any yelling of "DINNER!" goes unheard. James West had a similar problem, so he came up with a novel solution.

magpi.cc/XnQavf

PUSHING THE LIMITS

Some devices require human interaction to work. This fun device is an internet-connected button-pusher. Now, from anywhere in the world, you can start the coffee machine. Using Prota OS, your Raspberry Pi can trigger it too.

magpi.cc/Dfawlo

SMART LIGHTS ON THE CHEAP

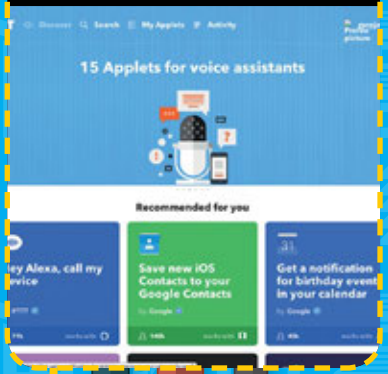
Smart lights are refreshingly inexpensive projects. With the optional £25 gateway, the whole ZigBee network becomes accessible to your Raspberry Pi. Our friends at Pimoroni have an excellent tutorial on controlling your lights in Python.

magpi.cc/eSrhME

IFTTT

An essential for anyone wanting to automate processes, IFTTT ('If This Then That') allows you to create behaviours by linking together different technologies and services. It makes adding voice control using Alexa or others a breeze.

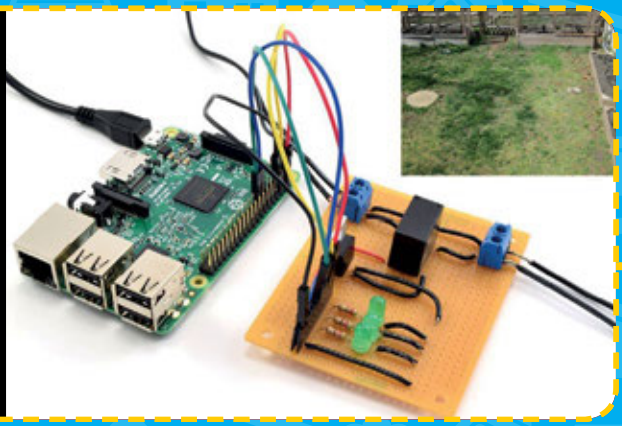
ifttt.com


15 Applets for voice assistants
Recommended for you
Save new iOS Contacts to your Google Contacts
Get a notification for birthday event in your calendar

PINGIN' IN THE RAIN

There are many automated garden irrigation projects to be investigated. This one, by Ben Fino, uses an API call to a weather service to determine whether it has rained recently. Others use rain detectors to record rainfall duration to prevent unnecessary wastage.

magpi.cc/lroEhD



COUNT YOUR CHICKENS

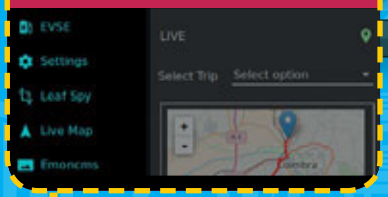
A very popular post from the Raspberry Pi archives that set off of a wave of automated chicken coops across the world. When your chickens need to be locked in every night, why not automate it?

magpi.cc/NlleLU

DON'T FORGET THE CAR

Many modern vehicles come with GSM radios and can relay data to the cloud. This project accesses data from a Nissan LEAF, which it can then use to trigger events. Arrive home and get the tea on with a MicroBot Push?

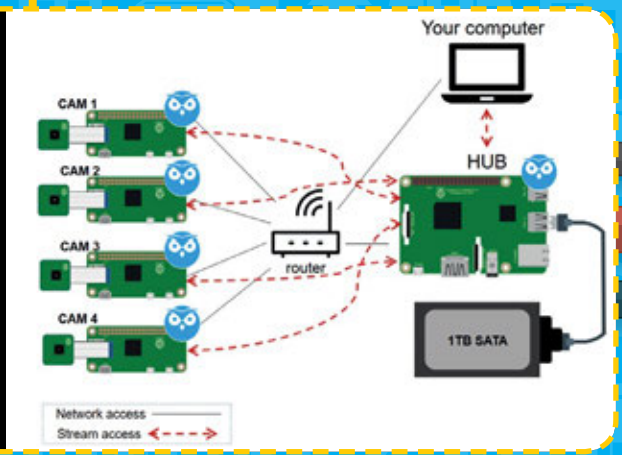
magpi.cc/BYMAlS



WHOLE-HOUSE SURVEILLANCE

A full CCTV rig is normally an expensive proposition and typically locked down to the manufacturer's services. Julian Silver's ambitious project uses four Pi Zeros with Pi Cameras governed by a Pi 3 which records all the incoming streams.

magpi.cc/FuUFKl



KITTYCAM – SMART CATS!

'Smart' cat flaps are nothing new, and work by detecting the cat's identification microchip to allow entry. Tomomi Imura's solution takes things a stage further with a PIR detector plus actual cat facial recognition to power a cat-cam!

magpi.cc/wAeqvn

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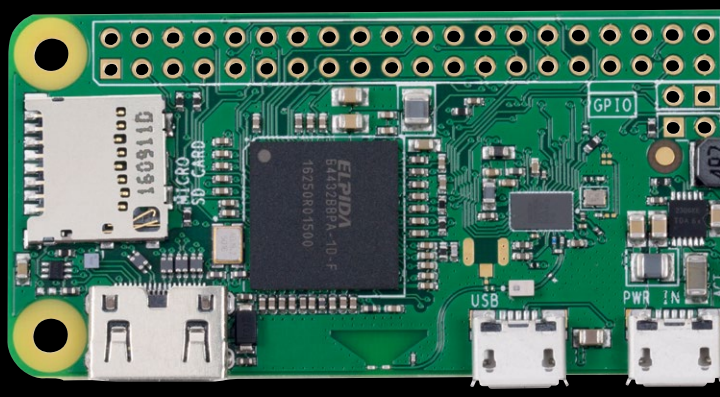

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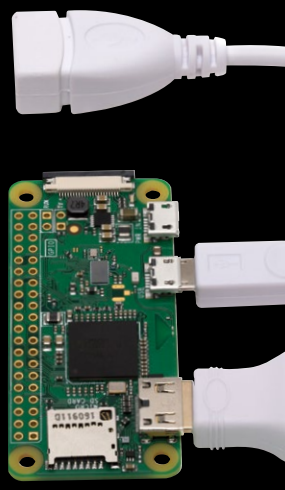

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The Pi 3, which is wired directly to a 5V DC-to-DC converter, displays on a Raspberry Pi 7-inch touchscreen with a resolution set at 800×600
The Pi 3 is booted with a flick of one of these switches. Power switch functionality comes via Petroblock's PowerBlock. Keyed input allows for proper boot and shutdown to ensure file integrity
The car is still driven using the accelerator and brake pedals, but the Pi makes use of data from the Tesla motor's custom controller provided by HSR Motors

JIM BELOSIC & MICHAEL MATHEWS

Jim is the CEO and co-founder of the digital marketing platform ShortStack, and Michael is one of the lead software engineers at the company. Both love modding cars. **magpi.cc/uRHPfq**

TESLONDA

Quick Facts

- The car is operated by toggle switches
- Jim wants to let it rip on the drag strip
- The software will be licensed for others to use
- A mobile web app can log and track functionality
- The car can go from 0–60 in 2.48 seconds

Jim Belosic and Michael Mathews have turned a Honda Accord into a hot rod gasser – powered by electricity and a Raspberry Pi. **David Crookes** gets up to speed

Many people remember their first car, but very few will keep hold of it for decades. Then again, not everyone is like Jim Belosic, a vehicle modder who saw great potential in his 1981 Honda Accord. Rather than sell it, he decided to bring it into the 21st century. And that meant fitting it with an electric motor from a salvaged Tesla Model S P85.

"I've been wrenching on something since I can remember," Jim says. "So turning the Accord into an electric car seemed like a good way of keeping it around for the nostalgia. I also figured that if I want to be able to modify cars in the future, I'd better learn everything I can about these kinds of vehicles now."

The work involved replacing the steering and suspension system and moving to a straight-axle front end to accommodate the battery pack. Jim also added some drag-race tyres. "It gave the car a ton of character," he says. But what makes the car rather special for us is Jim's integration of a Raspberry Pi 3. This was carried out by his car-modding and software-developing friend, Michael Mathews.

Motor monitoring

As well as powering the electronic dash, the Raspberry Pi allows for feedback and configuration of the motor hardware. It can constantly monitor the temperature levels of the batteries and motor to ensure the car is not being overexerted, and it can be used for both traction control and to change the voltage and amperage levels to the motor.

"For this particular project, I wanted to dive straight into the HTML5 Canvas element [which can draw graphics on the fly via JavaScript] because I figured if I could control how and when something was drawn to the screen, I could get it to run pretty decently on the Pi," Michael explains. "I could get a prototype up and running fairly quickly using web tech."

Above Michael Mathews spent a long time planning the design of the dash. He says the project was helped by "plenty of smart people in the Pi community having already created tons of building blocks"

Canvas, and he wanted the back end to listen to data from the motor's controller for incoming messages using a Node.js server via a WebSocket. At first, he had problems with the visual performance since he was getting below 20 frames per second and heavy spikes of lag.

He solved this by using a 'frame' to only get the back end to send the most updated data rather than every single message. He also minimised browser reflows, and enabled Canvas acceleration by turning on every relevant flag

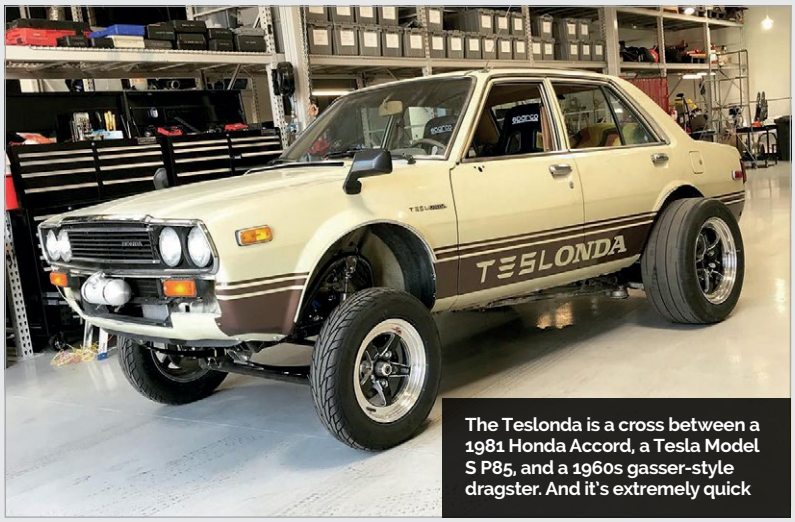
> "The Pi 3 boots with a fantastic display that's reminiscent of a 1980s arcade game"

One main goal was to make it semi-portable so that it could be stuffed into another project without much rework. "I also wanted to allow any device to connect to it via WiFi through a web server, and it needed the ability to monitor, control, and log data on the back end through a web app," Michael continues.

Canvas frames

To achieve all of this, Michael grabbed a pencil and paper to draw his desired UI and design flow. He opted to use the Chromium browser in its kiosk mode running an accelerated on Chromium. By making sure Canvas would only draw when something updated, and erased only what was dirty, he could maintain 45 to 60 fps on the dash.

The result is amazing. Turn the car on, flick a switch to activate the dash, and the Pi 3 boots with a fantastic display that's reminiscent of a 1980s arcade game. It shows the speed, battery voltage, charge, and temperature, among other attributes. "I'll soon be hooking up a GPS to assist with logging, acceleration, and G-force readings as well," Michael reveals. "And that's the only problem: I now want to do so much more."



The Teslonda is a cross between a 1981 Honda Accord, a Tesla Model S P85, and a 1960s gasser-style dragster. And it's extremely quick

LET'S GO, MR DRIVER

>STEP-01

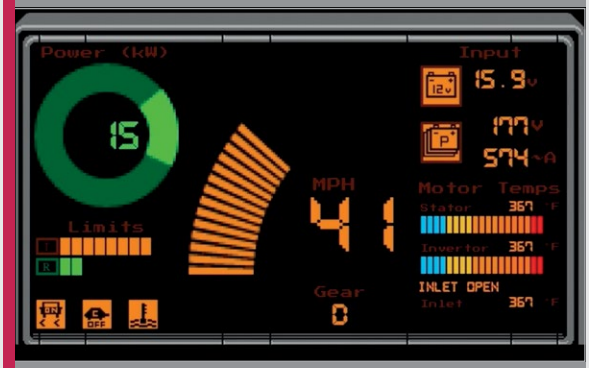
Booting up

When the Teslonda's Raspberry Pi 3 boots, it opens with a fun 1980s-style video-game sequence. The theme fits the 1981 vintage of the Honda Accord. "It needed to look fun," says Michael.

>STEP-02

High scores

There's a high score table of the fastest 0 to 60. "I did some research on what early 1980s digital dashboards looked like and found my inspiration – a Mitsubishi Cordia 1982 digital dash."



>STEP-03

Dashing dash

The dash shows the speed, gear, voltage, amp, temperature, power, and more. "I wanted the driving experience to feel like you're at the arcade. There's also a 'Continue?' countdown when the Tesla motor is turned off."

TIM JACOBS

Tim Jacobs is a coding and electronics guru who has created a large number of software and hardware projects. This is his first serious Pi project.
magpi.cc/OejcSh

Quick Facts

- A Polaroid Sonar AutoFocus 5000 was used
- The thermal printer cost £34 from Amazon
- Each reel of paper fits 300 to 400 images
- A USB hub expanded the Pi Zero's connectivity
- Most time was spent reducing Pi's boot time

THERMAL PAPER POLAROID

When Tim Jacobs sought to save money by creating an instant camera using inexpensive thermal paper, he didn't realise saving time was also a priority. **David Crookes** reports

With this amazing Pi-infused camera, there's certainly no shaking like a Polaroid picture. Instead, Tim Jacobs has done away with film entirely, so rather than instantly output white-bordered glossy pictures as per the original, it prints the results on the kind of thermal paper typically used for receipts.

Not only does this make for cheaper photography – "instant film is hugely expensive: more than £1 per shot," Tim explains – it retains the original premise thought up by scientist Edwin Land, who unveiled the first commercial instant camera back in 1948.

For Tim, however, it was a chance to finally put a long-held idea of his own into practice. "The noise that thermal printers make when they spit out receipts reminds me of instant cameras and I'd always wanted to use one for that purpose," he says.

Using Linux

To achieve his dream, Tim bought the smallest thermal printer he could find (an LESHP model with built-in Bluetooth and support for USB and RS232). He also made use of an old Polaroid camera, a Raspberry Pi Zero, and a £1.99 webcam ("the printer is only 384

Tim rewired this flash connector to allow a USB serial adapter to be plugged in, enabling communication with the Pi Zero without having to disassemble the camera

To make room for the printer, everything within the front mechanism had to be gutted. The project involved a lot of drilling and cutting

A Raspberry Pi Zero has been connected inside the casing. It is powered by a battery mounted behind the flap used for loading film cartridges

The paper roll has to be reloaded by pulling the front fascia off the camera. Tim would like to feed the paper via a motorised reel, but that's one for another day

pixels wide so, in terms of image quality, a better camera wouldn't make much difference"). From that point on, "it was 90 percent experimenting and 10 percent shoving it into a pretty case."

Before getting close to assembling the camera, Tim wanted to make sure he could actually get the printer to work with Linux. "It couldn't have been easier, it almost felt like cheating," he laughs. Getting it to print images directly from the webcam without mangling was more difficult, though. "It consumed more than an entire roll of paper."

> "When it comes to small Linux boards, Raspberry Pi is king"

But he persevered and eventually proved successful. He could then turn his attention to the Raspberry Pi Zero, a decision based on the small size of the computer and the large size of the community. "Almost every problem you encounter will have been solved and documented by someone already," he says. "Besides, when it comes to small Linux boards, Raspberry Pi is king."

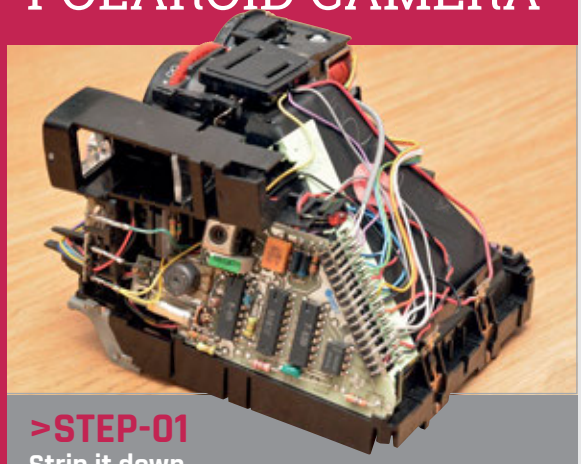
Boot times

Tim's main challenge was to reduce the boot time so that the camera would be ready to take a shot within seconds of it being picked up. Ideally, he wanted to be able to put the processor to sleep and have it wake instantaneously; with the Raspberry Pi unable to do this, however, he sought to shave many seconds off the boot time instead. He found that shooting, converting, and printing was also slow, initially taking 40 seconds from boot to result.

To solve this, he used buildroot to create a custom, bare-bones Linux image that contained everything the camera needed and nothing it did not, cross-compiling it into a minimal image. It took a long time to crack, but he managed to get the boot time down to just two seconds. Little tricks also sought to save small amounts of time, such as disabling the HDMI splash screen and preventing kernel messages being dumped to the serial port when the Raspberry Pi was booted.

When the components were placed into a dismantled Polaroid camera bought off eBay, it worked a treat. A USB hub was used to connect the webcam and printer and the process of assembly ensured that, from the outside, it looked like a normal camera. "There was cutting, drilling, and gluing dappled with the occasional bout of soldering," he explains. It was then ready to take a shot. "The only thing it lacks is the row of metal teeth that would let people tear off the picture after taking it. I'll have to add that sometime."

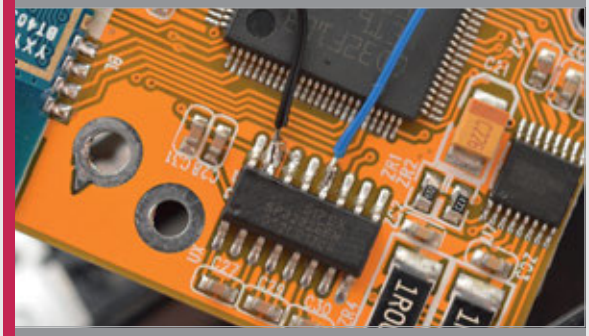
TRANSFORM A POLAROID CAMERA



>STEP-01

Strip it down

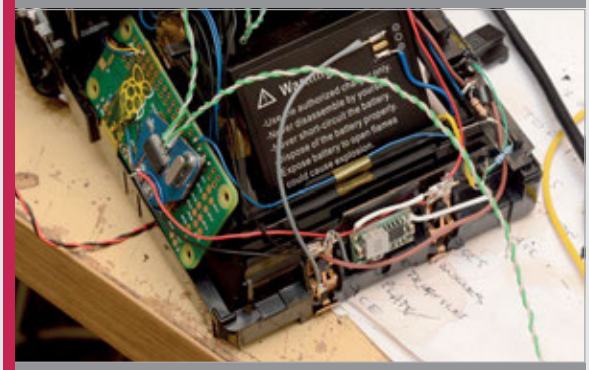
The Polaroid needs to be gutted, but there's only one screw in sight. "The number of intricate interlocking injection-moulded parts boggles the mind," says Tim. Even the lens had to go.



>STEP-02

Prepare the components

The printer and webcam were also stripped, the latter being focus-fixed to two metres. Before using the Pi, Tim considered (then rejected) reprogramming the ARM Cortex M0 chip on board the thermal printer.



>STEP-03

Assemble the camera

The thermal print head took ten hours to fit; the webcam and Pi much less time. Some of the Pi's GPIO pins were wired to the shutter switches, and the camera works with a single button press.

MICHAEL TEEUW

A Netherlands-based maker, Michael builds things both for work and pleasure.
michaelteeuw.nl

Quick Facts

- It uses a Pi 3 and Arduino Nano
- The UI is run using MagicMirror²
- Different inputs result in different effects
- NeoPixel LEDs light the way!
- Toddler-friendly and easy to use

ENZO'S ACTIVITY BOARD

Inspired by his young son's interest in bright lights and buttons, Michael Teeuw decided to build a child-friendly activity board. **Nicola King** finds out more...

A classic eight-digit display can be used as a countdown timer
Enzo turns the NeoPixel-lit knob to switch between TV cartoon characters shown on the screen
Pressing buttons is fun for a toddler, especially when they make sounds!
ENZO
99927189
Dinotrux

What do you do when your toddler keeps pressing all the buttons they can find in the house? As a skilled maker – known for creating the MagicMirror² framework (**magicmirror.builders**) – Michael Teeuw opted to create a high-tech activity board based around a Raspberry Pi 3 for his two-year-old son Enzo.

Activity boards can create visual, tactile, and auditory stimulation for young children. Michael had seen other activity boards on the maker scene and, over the period of approximately one year, he built his own version complete with light effects, audio, an eight-digit display, and plenty of buttons and switches.

"Every few weeks I added something new," recalls Michael. "Enzo was there all along the way. It was fun to see him discover the new additions whenever I added them. You'll be surprised how quickly a two-year-old picks things up."

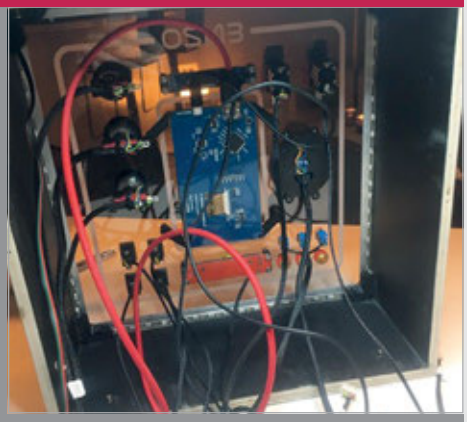
Child's play

Enzo has already figured out how to turn the rotary encoder knob – lit up impressively by a NeoPixel ring – to switch between his favourite TV cartoon characters shown on the screen. "Every input (buttons, switches, rotary encoder, slider pot) creates a different

BUILDING AN ACTIVITY BOARD

>STEP-01
Bits and pieces
Laying out all the components – buttons, switches, screen, NeoPixels, etc. – on a piece of paper enabled Michael to visualise the final board layout and see how much space was required.

>STEP-02
Cut the front panel
A transparent panel was required for the front of the Activity Board, so Michael created a bespoke design using the Fusion 360 package, then laser-cut it from a 4 mm acrylic sheet and engraved it.



>STEP-03
Wire it all up
After mounting the front panel on a wooden box, the screen was connected to the Raspberry Pi, while all the inputs were wired to an Arduino Uno-based control board.

light effect," explains Michael. "Combinations of different inputs result in different effects. So for every action, there is something for Enzo to enjoy. It will probably take some time before Enzo has discovered all the combinations."

Giving Enzo's Activity Board a classic mission-control look, the eight-digit display acts as a countdown timer which can be started by toggling one of the two main switches. "Whenever it reaches zero, the activity board will self-destruct. But for now, the self-destruction sequence isn't fully implemented yet!"

Magic Mirror

Driven by the Raspberry Pi, the Activity Board's central display shows a user interface that makes it more than just a box with lights and buttons. "It allows me to add features in the future," says Michael, "and is an easy way to add sound effects to the project." Rather than using the Raspberry Pi's own audio output, he elected to add an Adafruit Speaker Bonnet.

For the UI, the Raspberry Pi runs a default MagicMirror² installation with a custom module. "This module's node-helper reads out the serial input and sends it to the MagicMirror front end (which is a web application running on Electron)."

> "Every input (buttons, switches, rotary encoder, slider pot) creates a different light effect"

This user interface responds to the input it receives from an Arduino Nano-based control board which handles all the input (buttons, switches etc.) and output (NeoPixel LEDs, digital display).

"The lights and input are all controlled by [the Arduino board], which sends a serial JSON command to the Raspberry Pi whenever there is new input," reveals Michael. This separation of tasks means that the Activity Board's light effects can still function without the Raspberry Pi.

Young Enzo helped his father throughout the build process. "His enthusiasm for every update I showed him helped a lot in finishing the project."

As Enzo gets older, Michael plans to expand the functionality of the board by adding new user interfaces. "Hopefully, one day he'll be able to add his own UI."

Michael tells us he is still fine-tuning the software. "Like every piece of code, both the embedded code as well as the MagicMirror² module contains some bugs. It's up to Enzo to discover the bugs and send me a bug report."

Above Lit up like a Christmas tree, the board is placed at toddler height in a storage unit

STEFAN HÖVING

A bioengineering student from Germany, Stefan was taught woodwork and electronics from a young age by his father. He also enjoys a cocktail.
magpi.cc/uiTVEO

Quick Facts

- The machine took eight months to build
- Its GUI is programmed using PyQt
- Nine drinks can be mixed from five ingredients
- The LEDs flash when a cocktail is ready
- All the code is on GitHub: **magpi.cc/UVPtzS**

COCKTAIL MACHINE

A robotic bartender that can make cocktails to order? **Phil King** quenches his thirst... for knowledge

A custom GUI on a touchscreen offers a choice of nine cocktails
An air pump pushes liquid from any of five bottles to the outlet
The glass rests on a scale that measures the weight of each liquid being poured

What'll it be? Monkey wrench, swimming pool, zombie, painkiller? You can have any of these exotic drinks and more mixed by Stefan Höving's home-made cocktail machine (**magpi.cc/uiTVEO**), whose secret ingredient is a Raspberry Pi.

Bioengineering student Stefan came up with the idea for automated cocktails thanks to a friend who "would always pour way too much alcohol into the drinks when we would get together on the weekends... We basically needed something that can ensure that everyone always has the same composition of juice and booze, that would still be enjoyable."

Stefan was also looking for a project to practise his fledgling Python programming skills, learned during his part-time job at an analytical institute. "The first thing I had to do was program a graphical user interface in PyQt for a temperature control system," he recalls. While that never came to fruition, the GUI would eventually be put to good use in his cocktail machine, which offers a choice of nine drinks via a touchscreen display.

Tubes and valves

Housed in a handcrafted hexagonal wooden case, the cocktail machine

holds five bottles. Each is fitted with a shot dispenser with two tubes: air is pumped through one tube to force liquid up the other, which leads to a magnetic valve to turn the flow on or off. "From there, all five tubes (one for every bottle) are funnelled into the outlet that one can see above the glass," explains Stefan.

To ensure the correct volume measures are poured out, the platform where the glass is placed is a scale. "The first thing the program does after a cocktail is selected is [discount] the weight of the glass. I was surprised by how precise the scale actually is."

It did cause Stefan a headache during development, though. "For some reason, [its HX711 ADC] chip would produce random and really off values, although there was nothing on the scale. This would only happen when the machine was completely assembled. I reassembled the machine three times until I understood this behaviour." In the end, the annoyingly simple solution was to connect the VCC of the HX711 to 3.3V power instead of 5V.

Pumping air

Stefan also had a problem with the original aquarium air pump, which worked fine with one bottle but couldn't produce enough pressure to displace liquid from all five. "The gas volume of the five bottles combined was simply too high. So I got myself a bigger pump and it worked."

The air pump, magnetic valves, and LED lighting are controlled by an eight-channel relay board connected to the Raspberry Pi via a PCB with resistors. "For making easy connections, I soldered them and some plugging connectors to a PCB board. So I have easy access for maintenance purposes."

Equipped with bottles of rum, vodka, cola, orange, and pineapple, the machine can produce nine different cocktails using the recipes within the Python code – available from Stefan's GitHub repo (**magpi.cc/UVPtzS**) – but it could easily be adapted to produce other drinks, including non-alcoholic ones. "For new cocktails, you would have to adjust the ratios in the code accordingly."

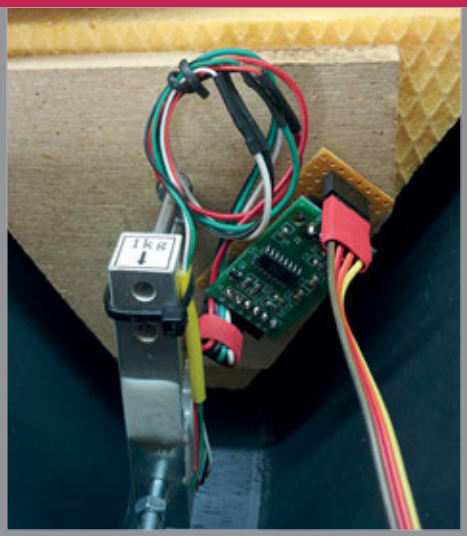
Dispensing liquid from each required bottle in turn, from the smallest to largest volume, helps to mix them in the glass. "A mechanical way of stirring might be possible," says Stefan. "However, I have not come up with an elegant solution so far... I am open to any suggestions."

Above The Raspberry Pi (left) is connected via a PCB to a relay board (right) wired to the air pump, magnetic valves, and LEDs

COCKTAIL MACHINE INGREDIENTS

>STEP-01
Making a case

Using his woodworking skills, Stefan made a hexagonal case with six triangular compartments: five for the bottles and the sixth for a platform to place the glass.



>STEP-02
Electronic scale

Under the platform is a scale comprising a load cell and an HX711 chip to amplify its signal to a readable level. The scale is used to measure the volumes of liquids added to the glass.

>STEP-03
Magnetic valves

An air pump pushes liquid from each bottle through a tube to a magnetic valve. When opened, this allows the flow of the liquid into the outlet to pour into the glass.

USE SSH WITH YOUR RASPBERRY PI

With SSH you can access a Raspberry Pi from another computer on your network

You'll Need

- Raspberry Pi
- Raspbian OS
- Another computer on the network

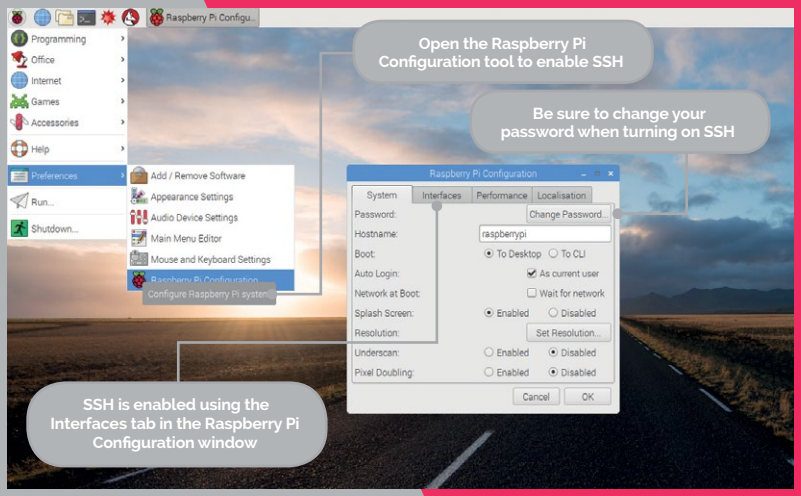
Secure Socket Shell (SSH) is a networking technology that makes it easy to securely access your Raspberry Pi from another computer on your network.

The small size of the Raspberry Pi makes it perfect for projects around the home. When setting up your Raspberry Pi device, you'll typically connect a keyboard, mouse, and display. But when you're deploying it in the home, for example as a retro gaming console or media box, then you won't want a keyboard and mouse attached to it.

More complex projects may even embed your Raspberry Pi in home devices where attaching a keyboard and mouse isn't practical, or even possible.

Having to extract your Raspberry Pi from its project and set it back up again every time you want to access it is a pain. And a needless one.

With SSH set up, and your Raspberry Pi connected to the same network as your laptop, you can connect to the Raspberry Pi using SSH and share files. You can also work on the command line, editing files and making changes (although to work with the Desktop you'll need to use a more advanced technology like VNC – Virtual Network Computing).

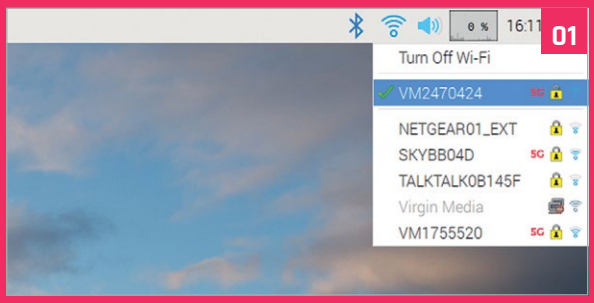

Open the Raspberry Pi Configuration tool to enable SSH
Be sure to change your password when turning on SSH
SSH is enabled using the Interfaces tab in the Raspberry Pi Configuration window

HOW TO: SET UP SSH IN RASPBIAN

>STEP-01

Connect to network

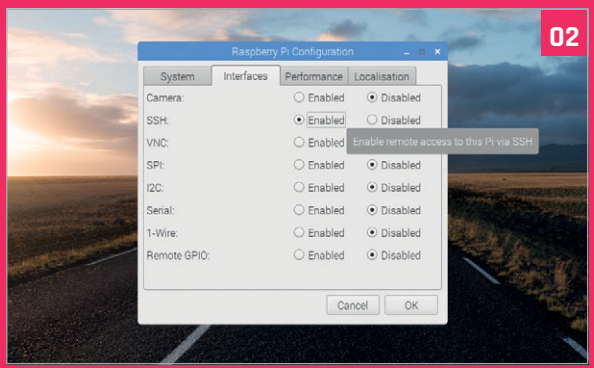
Make sure that your Raspberry Pi is connected to the network. Click on the Wireless & Wired Network Settings icon in the taskbar and choose a wireless network. Alternatively, connect directly via an Ethernet cable.



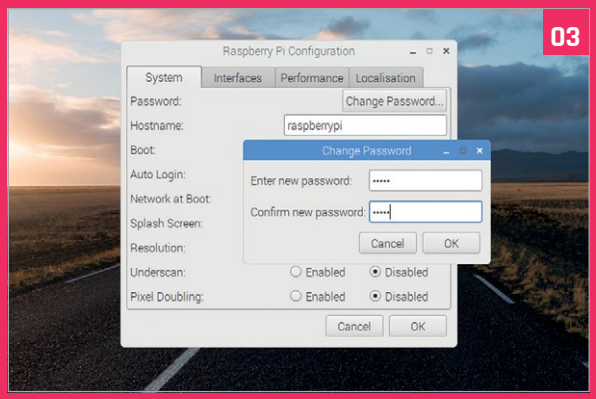
>STEP-02

Enable SSH

Click on the Raspberry Pi icon in the top-left of the screen and choose Preferences > Raspberry Pi Configuration. Click on the Interfaces tab and choose the Enabled radio button next to SSH.



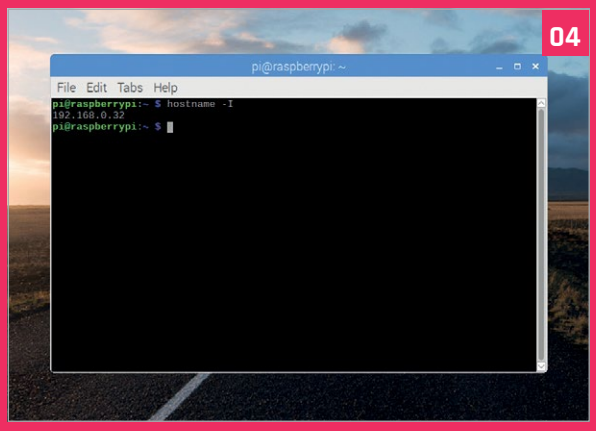
>STEP-03
Change your password
It's important to change the password for your Raspberry Pi when turning on SSH. While still in Raspberry Pi Configuration, click on the System tab and Change Password.



>STEP-04
Find your IP address
Open a terminal window on your Raspberry Pi (click on the Terminal icon in the taskbar). Now enter:

```
hostname -I
```

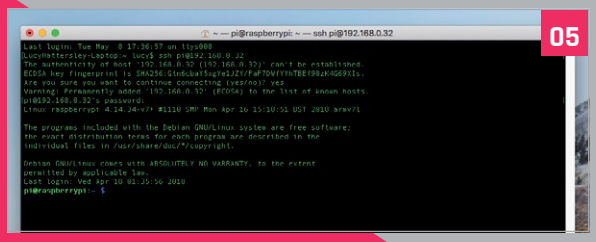
The four numbers (separated by dots) are your Raspberry Pi's IP (internet protocol) address. Write these numbers down.



>STEP-05
SSH from Linux, macOS, or Windows 10
You can use SSH to connect to your Raspberry Pi from a Linux or Windows 10 PC, or Apple Mac, without installing any additional software. Open a Terminal window (Command Prompt in Windows 10) and enter:

```
ssh pi@192.160.0.32
```

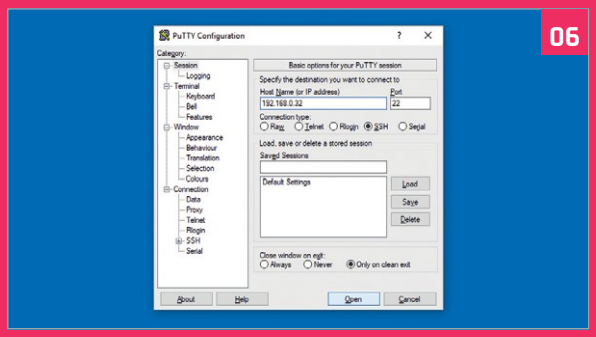
Remember to use your own IP address (from Step 4) after the @ symbol. Enter **yes** and press **RETURN** to connect to the terminal. Enter **ls** to view the directory files on your remote computer, and **exit** to log out.



>STEP-06
SSH on older Windows PCs
Using SSH on a PC with an older Windows version requires you to download software called PuTTY (**putty.org**). Download and install it on your PC.

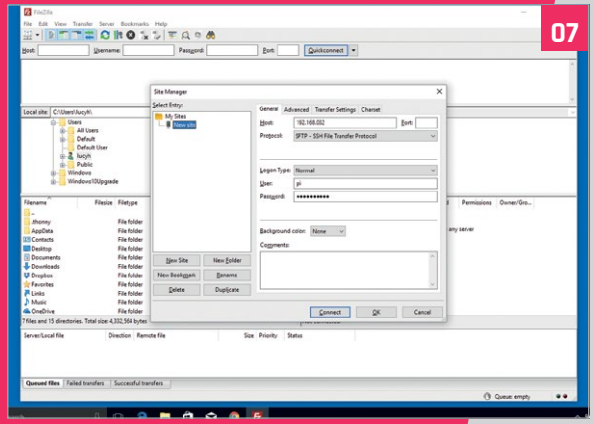
Open PuTTY and enter the IP address in the Host Name (or IP address) field. Click Open and then Yes in the PuTTY Security Alert window.

Enter **pi** when you see 'Login As:' and press **RETURN**. Now enter the password you created in Step 3.



>STEP-07
Transferring files
You can transfer files to and from your Raspberry Pi via SSH using file transfer software. Our favoured program is FileZilla Client (**filezilla-project.org**), which is available for Windows, macOS, and Linux. Deselect WebAdvisor and Avast Antivirus (or any other software bundled with the installer for Windows).

Choose File > Site Manager and New Site. Enter the IP address in the Host field and choose SFTP in the Protocol drop-down menu. Change the Logon Type to Normal and enter **pi** in the User field and your password (from Step 3) in the Password field. Click Connect and OK.



MIKE'S PI BAKERY

MIKE COOK

Veteran magazine author from the old days and writer of the Body Build series. Co-author of *Raspberry Pi for Dummies*, *Raspberry Pi Projects*, and *Raspberry Pi Projects for Dummies*.

magpi.cc/259aT3X

You'll Need

- Magnetic Bounce interface – *The MagPi* #69
- LEDs and drivers not required

BUILD A THEREMIN

Use a magnetic bounce controller to generate live customised sounds from the Raspberry Pi with Pure Data

Last issue we showed you how to make a magnetic bouncing interface. This month we will demonstrate how to use this to generate and control your own sounds, using the magnetic bouncing interface as a theremin. The theremin, designed in 1928 by Léon Theremin, perhaps defines the average person's view of what outer space sounds like and is played with two hands, the position of one defining pitch and the other defining volume. We will use the two bouncers from last month in the same way. Note you will not need the LEDs from last month's project here.

Pure Data

Pure Data, or Pd as it is often abbreviated, is on the short list for one of the worst names for a computer language, although we think that Processing just beats it. We have not looked at Pd before in the Bakery, although we have used it on and off for many years. We think it deserves a wider exposure in the Raspberry Pi world. It was designed by Miller Puckette in the 1990s as an interactive computer language for generating and manipulating sound. At that time, what we now call open-source software was known as 'public domain software', so maybe that explains the name. At the same time, Miller was designing a commercial version of the same concept known as MAX, later to be MAX MSP, with some other people. All these years later, both Pd and MAX are still going strong. The two are very similar in function, but MAX has the slicker-looking graphics. The way it works is that functional blocks are placed on the screen and are then wired together to make connections between the blocks.

Installing Pd

We used the latest Pi 3B+ compatible version of the operating system and the installation process is as painless as it comes with Linux. Simply open a Terminal window and type:

```
sudo apt-get install pd-comport
```

It takes less that three minutes to install. This downloads what is called the 'vanilla' version; there are other, maybe better versions, but they're all no longer being maintained so it's best to stick with

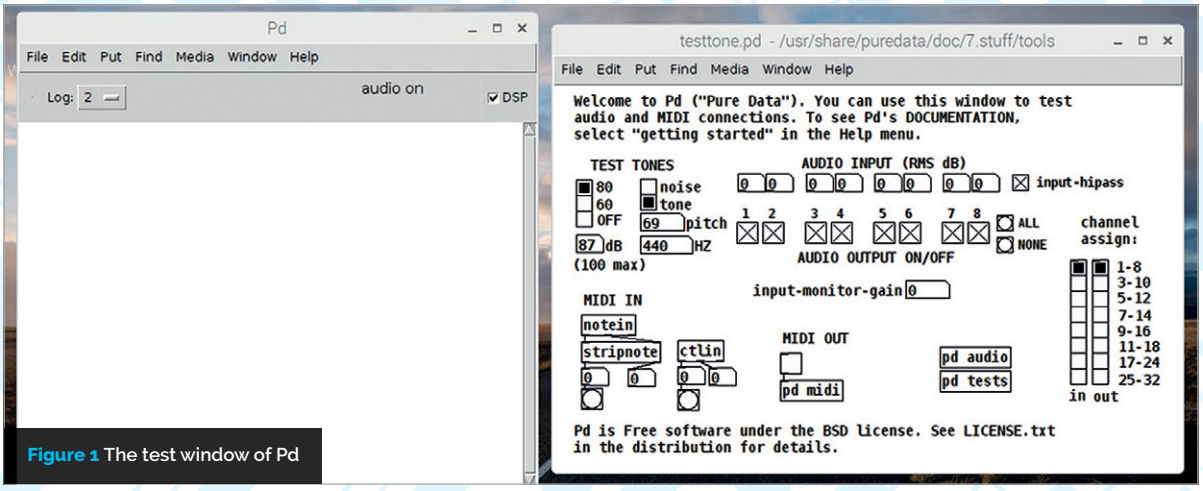
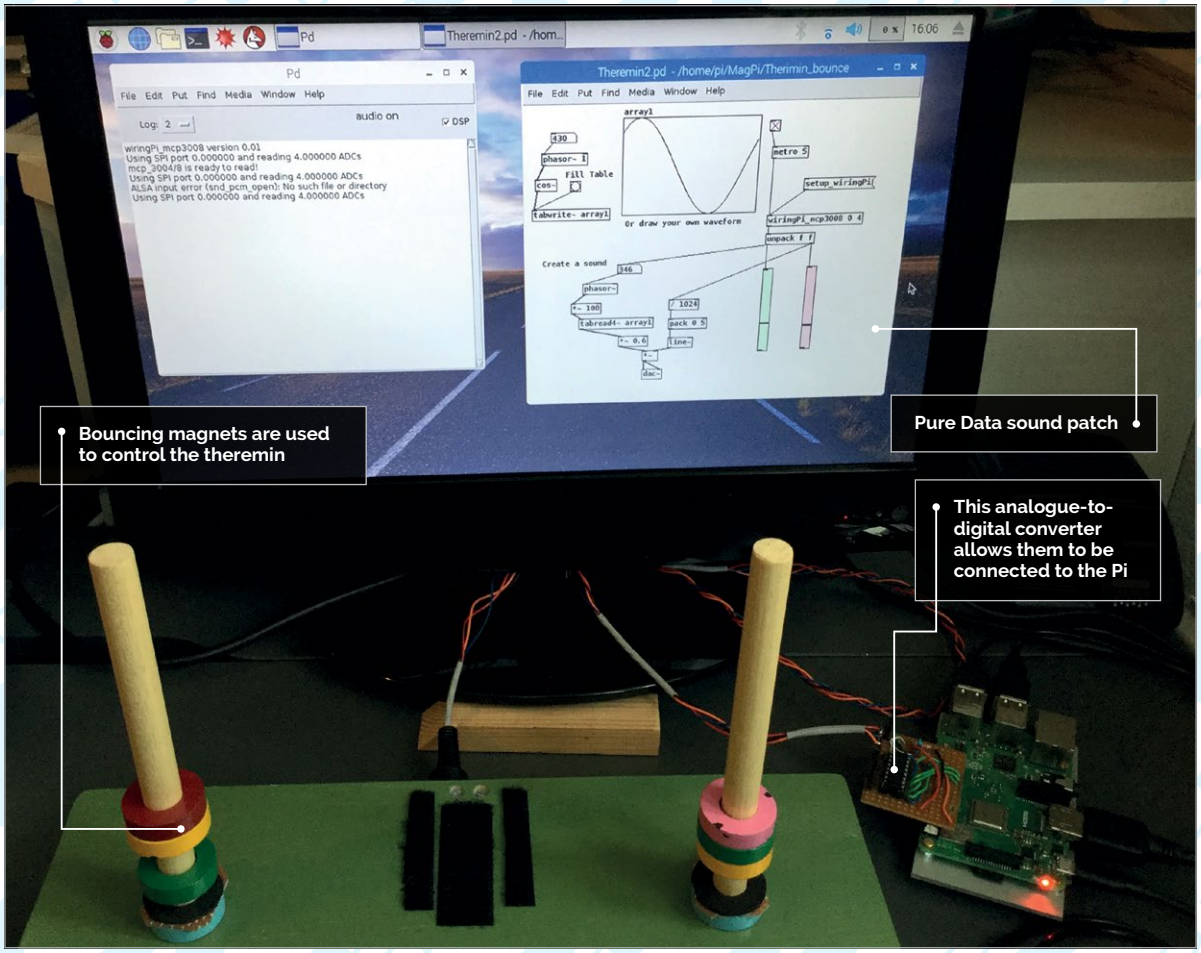


Figure 1 The test window of Pd


Bouncing magnets are used to control the theremin
Pure Data sound patch
This analogue-to-digital converter allows them to be connected to the Pi

this version. What we need to do is to install an extension so that Pd can interact with the Pi's GPIO port. This is done through the intermediate WiringPi library, so this needs to be installed first. You can do this by following the installation instructions at **magpi.cc/wnXSkT**.

Note: we had to uninstall the built-in version in order to use the latest version, which is 2.46.

Finally, we need the code that links WiringPi to Pd; you can get this from **magpi.cc/TZYnvG**. This comes in the form of a .tar file; to decompress this, navigate to the **Downloads** folder in a Terminal window and type:

```
tar -vxf Pd-wiringPi.tar
```

Drag the resulting **Pd-wiringPi** directory to the **home/pi** directory, and that should be it. Despite what the **ReadMe** file says, there is no need to compile anything – all that remains to be done is that Pd needs to know where to search for these files, but we will do that later. So let's fire up Pd and start exploring this new language.

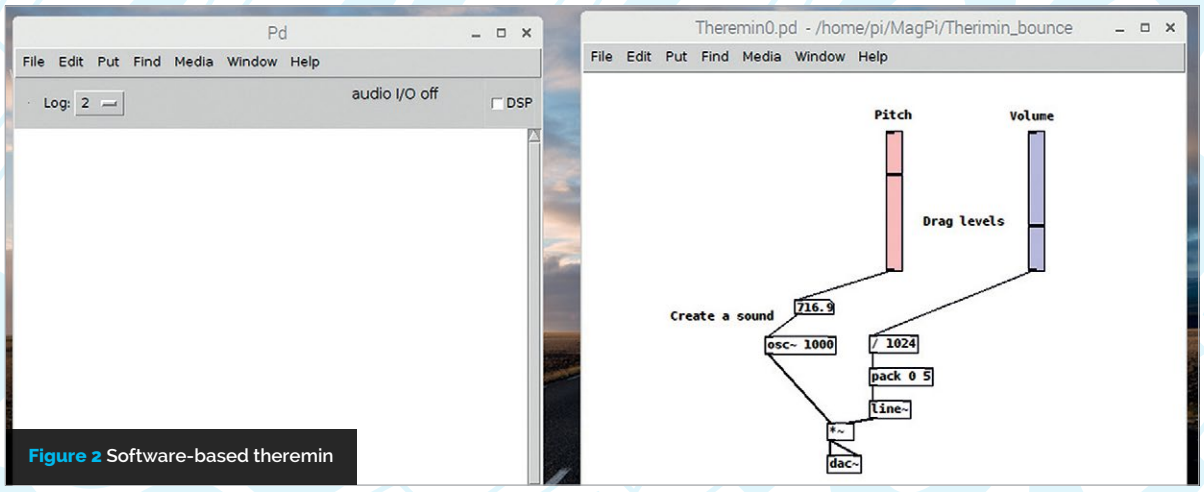


Figure 2 Software-based theremin

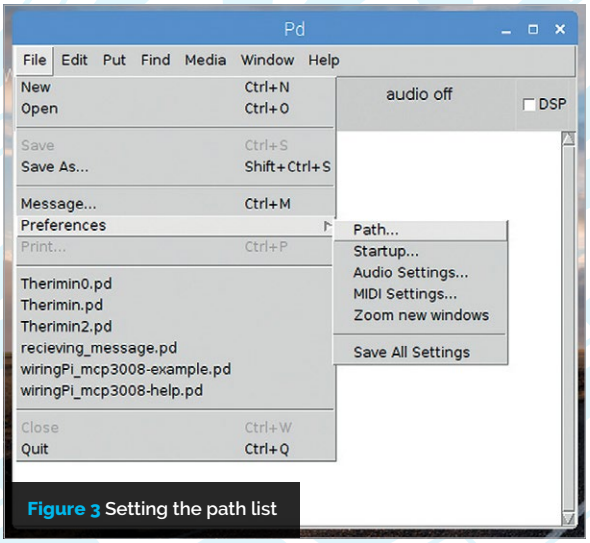


Figure 3 Setting the path list

Using Pd

Pd can be started from the main menu, under Sound & Video. You might read on the net that you have to run it in supervisor mode otherwise it crashes, but that is no longer true. The first thing to do is to test that you can get a sound out of the system, so go to the Media menu and select 'Test Audio and MIDI…'; you'll get another window that is shown in **Figure 1**. Click on the box with 80 in it and you should hear a tone; click and drag the pitch or Hz boxes to change the tone's pitch, or drag the dB box to change the volume. You will notice that the DSP box in the right-hand corner of the original Pd window has become ticked. This stands for 'digital signal processing' and in effect turns the processor-intensive sound-generating part of the code on and off. There are lots of other basic tests you can do from this window, but we don't need to bother with them at the moment, so close the window.

Go to the Media menu and select 'Audio Settings…', then disable the inputs by unticking the input devices box, click Apply, and then 'Save all settings'. This is so you don't waste processor power to input something that will not be used here.

Let's make our first 'patch', as a program is called in Pd. You can do this graphically, but for the moment let's be unconventional and type it in. Open up a text editor, type in the code in the **Theremino.pd** listing, and save it with that name. Now go to the File menu in the Pd window and select Open; find the file you just typed and open it. The result should be as in **Figure 2**. Make sure the DSP box is ticked and you should hear a tone; dragging the two sliders in the top left of the box should change the volume and pitch of the tone being produced.

How it works

Some words or symbols in these boxes have a tilde (~) at the end of the name. This indicates that this is a waveform function, one that only runs when the DSP box is ticked. So the pitch slider generates a value (this was set to be 0 to 1024) and passes it onto an oscillator box, osc~. This is then passed to a waveform multiplier box, *~, which is also being fed another number from the volume slider. Multiplying a fixed number with a waveform generates a change in amplitude, or volume, of the waveform. This volume number should be between 0 and 1, which is what the /1024 box does. Note that there's no tilde here, as this does no need to be done at waveform speeds. The pack and line~ boxes add a bit of smoothing. The output of the *~ box feeds into both left and right channels of a dac~ box. This is a digital-to-analogue converter which is your audio output; note that it can be stereo, but here we use it as mono.

Adding external control

So next we want to take these control signals not from on-screen sliders but from our magnetic bounce interface, through the MCP3008 A/D converter connected to the GPIO pins. To do this we have to tell Pd where these extension files are, or rather add to the list of places to search when Pd can't find a function. So in the File menu, go to Preferences and choose 'Path…', as shown in **Figure 3**. A window will pop up

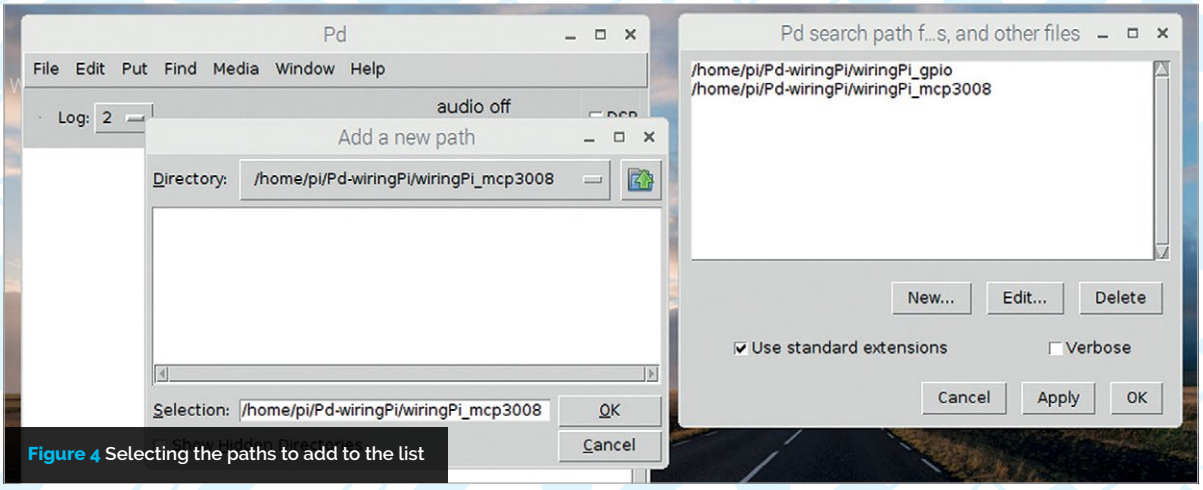


Figure 4 Selecting the paths to add to the list

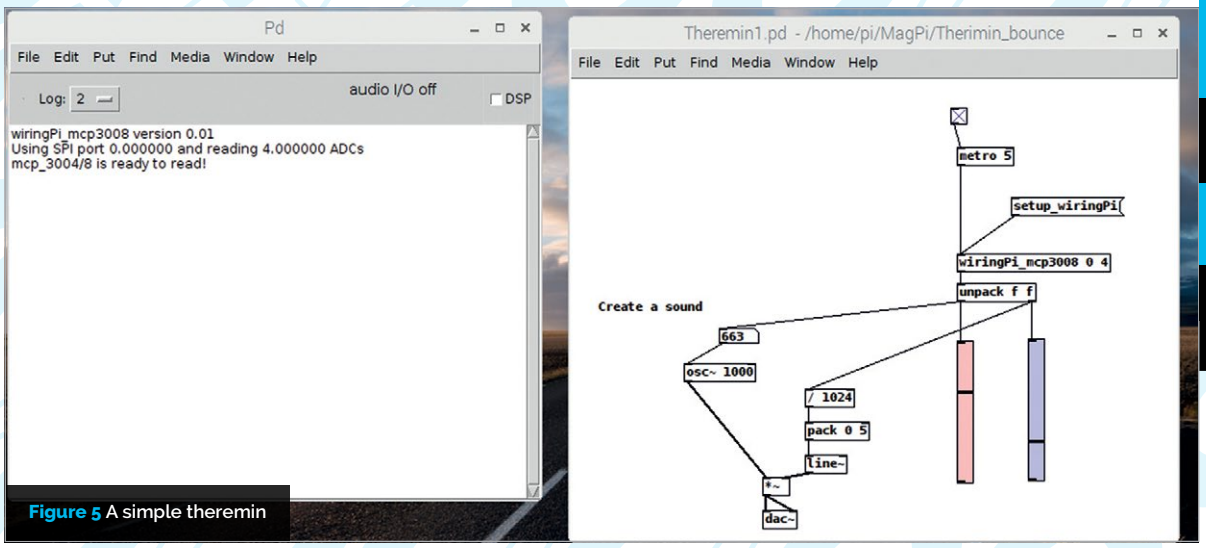


Figure 5 A simple theremin

allowing you to navigate to the directory containing these extension files. Click on New and navigate to the wiringPi_gpio extensions, then repeat and navigate to the A/D extensions. The result should look something like **Figure 4**; click on Apply and the job is done.

Next, type in the code from the **Theremin1.pd** listing and save it as that name. Open it up from Pd and you should see the window shown in **Figure 5**. Now, to activate wiringPi, click on the setup_wiringPi box, and also click on the box above the metro box to make sure it has a cross in it. You should now see the sliders move up and down according to the magnets' positions, and if the DSP box is ticked you'll hear the sound respond accordingly.

Different sounds

We can make different sounds by defining a different shape of waveform, but don't think we can make it sound like anything we want, because that is a lot more complex and involves changing the waveform continuously during the duration of a note. We can make any waveform we want by using a lookup table to define each point in the wave. This time we are going to modify the last program graphically to do this. So perform a 'Save as' on the last code and call it **Theremin2.pd**. Make sure the DSP box is not ticked and go to the Edit menu in this window and select 'Edit Mode' so that the menu item becomes ticked. This puts Pd into the graphical edit mode where the mouse clicks behave differently. We are going to reproduce the patch in **Figure 6**. First off, click on the osc~ box so it is highlighted and then press the **DELETE** key to remove it. Then, from the Put menu, select Object and click on the top-left area to give a dotted box with a blinking cursor. Type **phasor~ 1** and click off the box. Repeat this and create the boxes cos~, tabwrite~, phasor~ 1, *~ 100, tabread4~ array1, and *~ 0.6. Then select 'number' from the Put menu and click in the window. It will show up with zero in it; drag it up to the top right-hand corner. Select Array from the Put menu and place the box where you see it in **Figure 6**. Finally, select 'bang' from the Put menu and place that to the right of the cos~ box.

Having placed all the components, you need to wire them up. Hold the mouse over the double thick line at the bottom left of the cos~ box and the cursor will turn into a circle. Drag the mouse to the double thick line at the top right of the tabwrite~ box and release when the cursor again turns into a circle. A wire will

Language
>PURE DATA

DOWNLOAD:
magpi.cc/1NqJjmV

PROJECT VIDEOS

Check out Mike's Bakery videos at:
magpi.cc/DsjbZK

Theremin0.pd

```
001. #N canvas 591 102 572 459 10;
002. #X obj 288 57 vsl 15 128 0 1023 0 0 empty empty empty
     0 -9 0 10 -261234
003. -1 -1 9300 1;
004. #X obj 423 57 vsl 15 128 0 1023 0 0 empty empty empty
     0 -9 0 10 -203904
005. -1 -1 11100 1;
006. #X obj 272 280 pack 0 5;
007. #X obj 272 311 line~;
008. #X obj 232 332 *~;
009. #X obj 232 363 dac~;
010. #X text 81 223 Create a sound;
011. #X obj 173 250 osc~ 1000;
012. #X floatatom 201 215 5 0 0 0 - - -, f 5;
013. #X obj 272 249 / 1024;
014. #X text 321 133 Drag levels;
015. #X text 403 33 Volume;
016. #X text 275 32 Pitch;
017. #X connect 0 0 8 0;
018. #X connect 1 0 9 0;
019. #X connect 2 0 3 0;
020. #X connect 3 0 4 1;
021. #X connect 4 0 5 0;
022. #X connect 4 0 5 1;
023. #X connect 7 0 4 0;
024. #X connect 8 0 7 0;
025. #X connect 9 0 2 0;
```

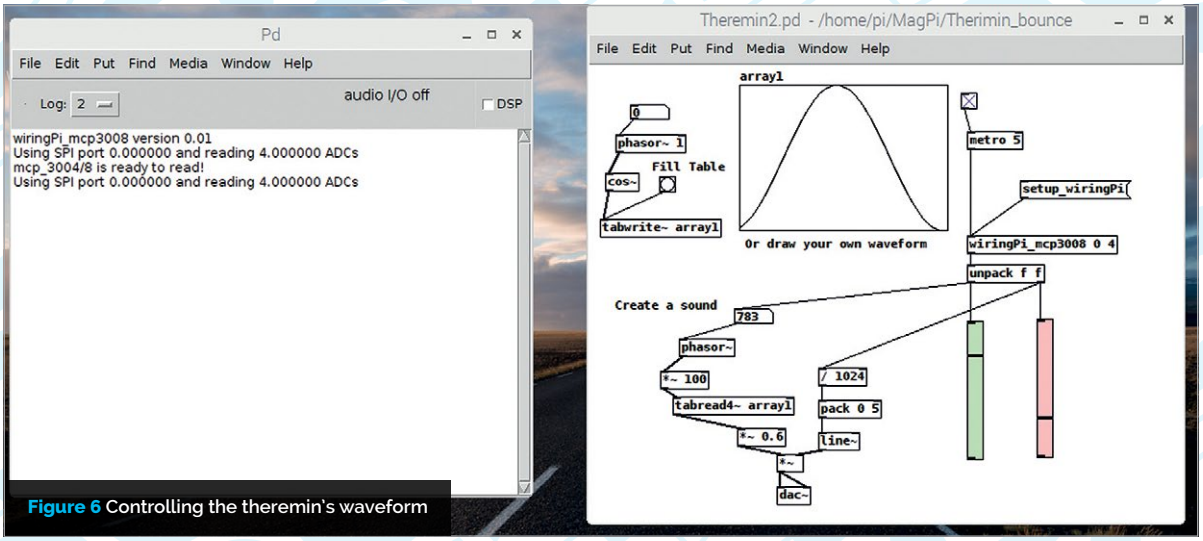


Figure 6 Controlling the theremin's waveform

Theremin1.pd

```
001. #N canvas 521 105 572 459 10;
002. #X obj 358 27 tgl 15 0 empty empty empty 17 7 0 10
     -262144 -159808
003. -1 1 1;
004. #X msg 415 111 setup_wiringPi;
005. #X obj 364 248 vsl 15 128 0 1023 0 0 empty empty empty
     0 -9 0 10 -261234
006. -1 -1 7076 1;
007. #X obj 431 246 vsl 15 128 0 1023 0 0 empty empty empty
     0 -9 0 10 -203904
008. -1 -1 3377 1;
009. #X obj 364 64 metro 5;
010. #X obj 364 164 wiringPi_mcp3008 0 4;
011. #X obj 364 192 unpack f f;
012. #X obj 221 322 pack 0 5;
013. #X obj 221 353 line~;
014. #X obj 181 374 *~;
015. #X obj 181 405 dac~;
016. #X text 24 206 Create a sound;
017. #X obj 107 267 osc~ 1000;
018. #X floatatom 140 234 5 0 0 0 - - -, f 5;
019. #X obj 221 291 / 1024;
020. #X connect 0 0 4 0;
021. #X connect 1 0 5 0;
022. #X connect 4 0 5 0;
023. #X connect 5 0 6 0;
024. #X connect 6 0 2 0;
025. #X connect 6 0 13 0;
026. #X connect 6 1 3 0;
027. #X connect 6 1 14 0;
028. #X connect 7 0 8 0;
029. #X connect 8 0 9 1;
030. #X connect 9 0 10 0;
031. #X connect 9 0 10 1;
032. #X connect 12 0 9 0;
033. #X connect 13 0 12 0;
034. #X connect 14 0 7 0;
```

be drawn between them indicating that the output, bottom of the cos~ box, is connected to the input of the tabwrite~ box. Once boxes are joined like this, you can drag them around and they still stay connected. Wire up the other boxes according to **Figure 6**. The sketch is now complete, although you might want to add text to match **Figure 6**, with the Put menu's Comment option.

Running the patch

To run the sketch, take Pd out of edit mode with the Edit menu's 'Edit Mode' option and click the DSP tab. Click and drag on any numbers you need to change to make them the same as **Figure 5**, then click the 'Bang button' connected to the tabwrite~ box, to produce a continuous, smooth sine wave. You can draw in the array1 window with a click and drag to draw any waveform you want; note that any discontinuity between the start and end of the wave will be heard as a rasp-like edge to the note. As most of Pd is actually written in Pd, like so many extensible languages are, if you want to know about a block, simply right-click on it and select Help from the pop-up menu.

Taking it further

Try adding an offset to the bounce pitch sensor to change the range over which it bounces. Also, see if you can turn the notes from a continuous slide to discrete notes; there is a box that will do that. We have barely begun to even scratch the surface of this powerful language: it is capable of handling MIDI and OSC messages in and out, as well Python and Processing communication. It can be used to generate not only sounds, but musical scores, sequencers, synthesizers of various sorts, sample manipulation, and Fourier analysis. It will even handle video clips in a VJ way. There is a wealth of online support including a forum and tutorials that help you get the best out of this language. A good start is with the official documentation at **puredata.info/docs**. However, a possibly simpler read is the excellent guide at **magpi.cc/jvosCI**.

(Hello World)

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BEN NUTTALL

Ben is the Raspberry Pi Foundation community manager and your first stop to find out about anything Raspberry Jam related.
raspberrypi.org

MAKE A TWEETING BABBAGE BEAR

Turn the Raspberry Pi bear into Twitter's hottest new photo bot

You'll Need

- Raspberry Pi Camera Module **magpi.cc/28ljlsz**
- A push-button
- A cuddly toy – preferably Babbage!
- Some wire

In this project you will turn an old cuddly toy into a Twitter bot that can post pictures to your Twitter feed at the push of a button.

By creating a tweeting Babbage, you will learn how to use the GPIO pins and a button to trigger the Camera Module, automate a Python script to run when the Raspberry Pi boots, and embed a Raspberry Pi inside a Babbage Bear.

The first stage of this project will involve taking a picture with the help of the Pi Camera Module and saving the image file on your Raspberry Pi.

So, to begin with, your program should take a photo using the Camera Module, and save the photo using a timestamp as the file name.

To use the Camera Module, you will first need to connect it to your Raspberry Pi. Disconnect your Pi from its power source before starting.

The flex cable of the camera inserts into the connector (marked 'Camera') between the Ethernet and HDMI ports, with the silver connectors facing the HDMI port. Open the flex cable connector by pulling the tabs on the top of the connector upwards and then towards the Ethernet port. Firmly insert the flex cable into the connector while taking care not to bend the cable at too sharp an angle. Push the top part of the connector towards the HDMI connector and down while holding the flex cable in place.

Note that on a Pi Zero, the Camera port is on the edge of the board, but cable connection is similar.

Turn your Raspberry Pi back on and then make sure that the camera is enabled: click on the Menu > Preferences > Raspberry Pi Configuration. Then ensure that the radio button for Camera in the Interfaces tab has been checked.

Finally, you'll want to test that your camera is working. The easiest way to do this is to open a Terminal window and type the following:

```
raspistill -k
```

You should see a preview image displayed on the screen. You can exit the raspistill program by typing **X** and then pressing **ENTER**.

Taking photos with Python

You can use Python and the picamera module to take photos with the Raspberry Pi and its Camera Module. Create a new Python script by opening Thonny Python IDE from the Programming section in the Menu, and then selecting File > New. At the top, we import the **PiCamera** class and create a **camera** object.

```
from picamera import PiCamera
camera = PiCamera()
```

To take a photo, you can use the **capture()** method. To do this, you need to tell Python where you would like the photo to be stored and what you would like

it to be called. In the example below, the photo will be called **selfie.png** and will be stored in the **/home/pi/** directory.

```
from picamera import PiCamera
camera = PiCamera()
camera.capture('home/pi/selfie.png')
camera.close()
```

Run your code and then check to see the file **selfie.png** is present.

Adding a timestamp

The Python datetime module is incredibly useful for creating timestamps. First you'll need to import the datetime module, and specifically its datetime class.

```
from datetime import datetime
```

If you type this into Thonny's Shell pane and then **print(datetime.now())**, you should see an output similar to **2018-05-25 15:16:00.122396**.

Note however that you can't use this datetime object as a timestamp, since it is not a string. Instead, you need to use a formatter to extract the object's data into a string.

There are lots of ways to format the datetime object to extract different types of data. Try the following lines of code and compare the output strings.

```
now = datetime.now()
print("{0:%Y}".format(now))
print("{0:%a}".format(now))
```

The **{ }** is used as a placeholder within the string to be printed, while the **0** tells the **print** command to use the 0th object that is passed to it. In this case, that object is **now**. The **:%Y code** tells the **print** command to take the full year from the **datetime.now()** object.

You can chain these codes together, for example like this:

```
now = datetime.now()
print("Today is the {0:%W} of {0:%A} of
{0:%Y}".format(now))
```

If you want to use the timestamp to name a file, you might want to use a shorter form. For instance:

```
now = datetime.now()
filename = "{0:%Y}-{0:%m}-{0:%d}".
format(now)
```

Take a look at **strftime.org** to find other codes you can use with the datetime module.

Triggering a photo with a button

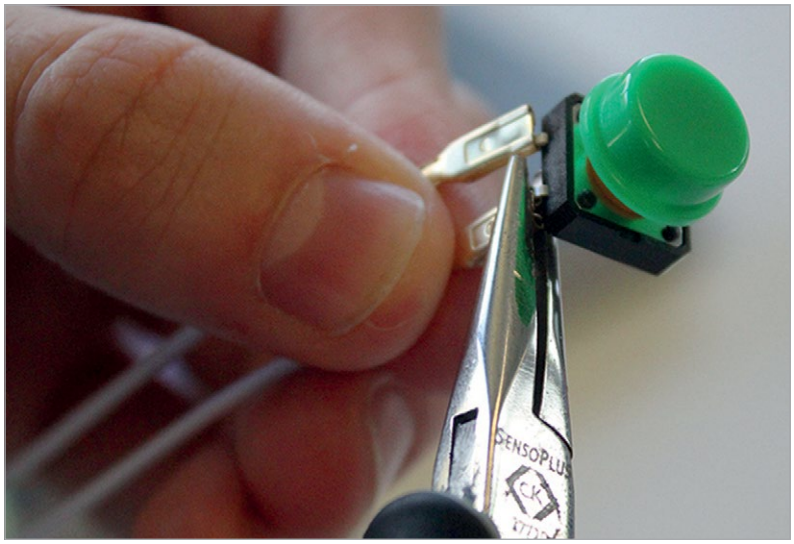
In this project, your Raspberry Pi will eventually end up being embedded inside your cuddly toy, so using a breadboard to wire up a button would be a little impractical. Instead you're going to connect it to the Pi with some quick-connect wires.

Connect the button to the wires and attach it by clamping with a pair of pliers.

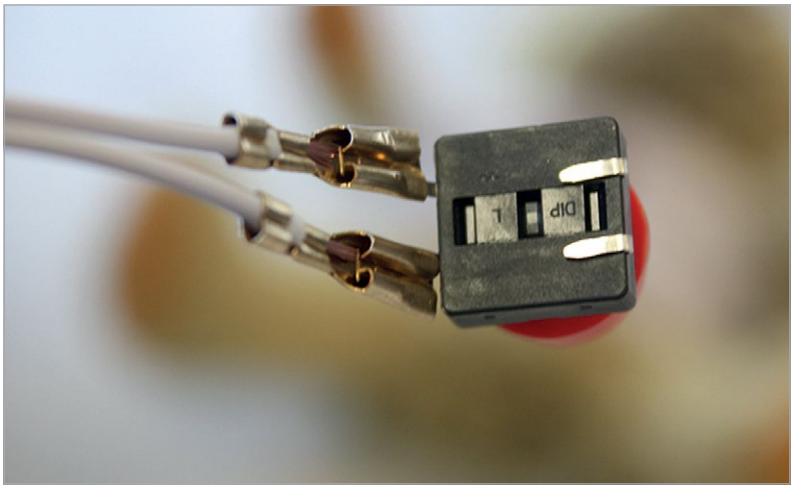
Language
>PYTHON

NAME:
tweeting_babbage.py

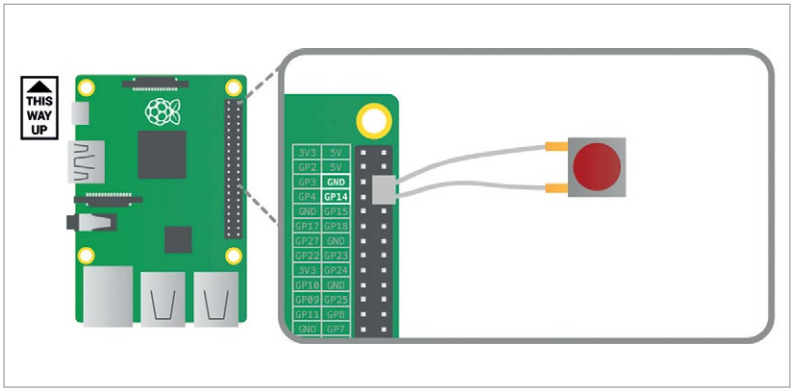
DOWNLOAD:
magpi.cc/KhyCDg



Flatten the remaining two button feet.



Wire it up to the ground pin and GPIO14 like so:



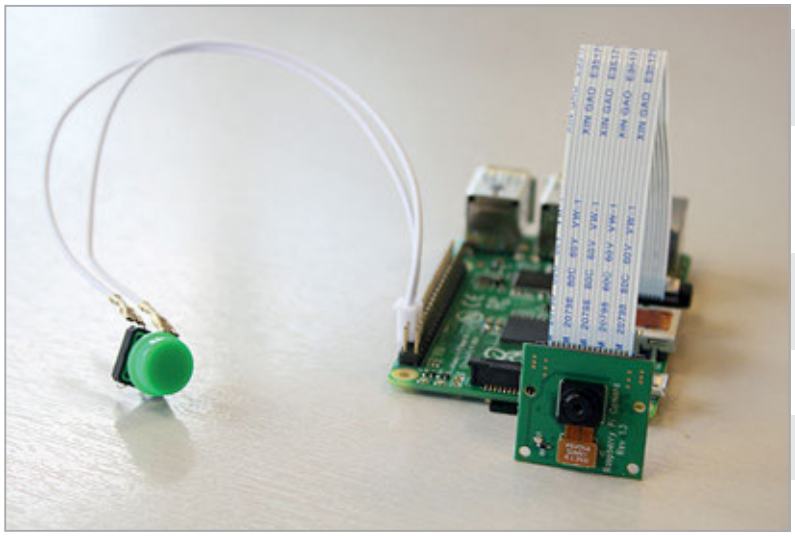


Figure 1 Button and camera connected

With your camera connected, your finished setup should look something like **Figure 1**.

The **when_pressed** method for the Button class in gpiozero can be used to call any function you have written.

Your first step will be to create a new function called **take_photo**. Inside this function you should place code to get the timestamp, save it as a global variable, and take the photo. Then write code to call this function when the button is pressed.

Creating functions in Python

Functions are named blocks of code that perform a defined task. Just about the simplest function you can create in Python looks like this:

```
def hello():
    print('Hello World!')
```

You tell Python that you're creating a new function by using the **def** keyword, followed by the name of the function. In this case it is called **hello**. The parentheses after the function name are important.

The colon at the end of the line indicates that the code inside the function will be indented on the next line, just like in a **for** or **while** loop or an **if/elif/else** conditional.

You can call a function by typing its name with the parentheses included. So to run the example function, you would type **hello()**. Here's the complete program:

```
def hello():
    print('Hello World!')
hello()
```

Using a button in Python

You can use the button to call functions that take no arguments. First, you need to set up the button using Python 3 and the gpiozero module.

```
from gpiozero import Button
btn = Button(14)
```

Next, you need to create a function that has no arguments. This simple function will just print the word **Hello** to the Shell window.

```
def hello():
    print('Hello')
```

Finally, create a trigger that calls the function.

```
btn.when_pressed = hello
```

Now each time the button is pressed, you should see Hello being printed to the Shell pane.

Your function can be as complex as you like – you can even call functions that are parts of modules. In this example, pressing the button switches on an LED on the GPIO04 pin.

```
from gpiozero import Button, LED
btn = Button(14)
led = LED(4)
btn.when_pressed = led.on
```

Combine all these to create your photo-taking button.

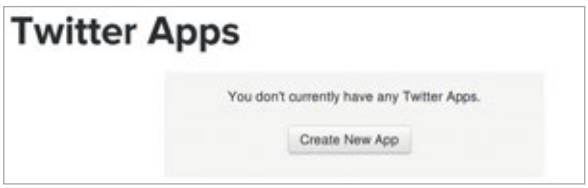
Connecting to Twitter

The next step is to post your photo, along with an accompanying message, as a Twitter update.

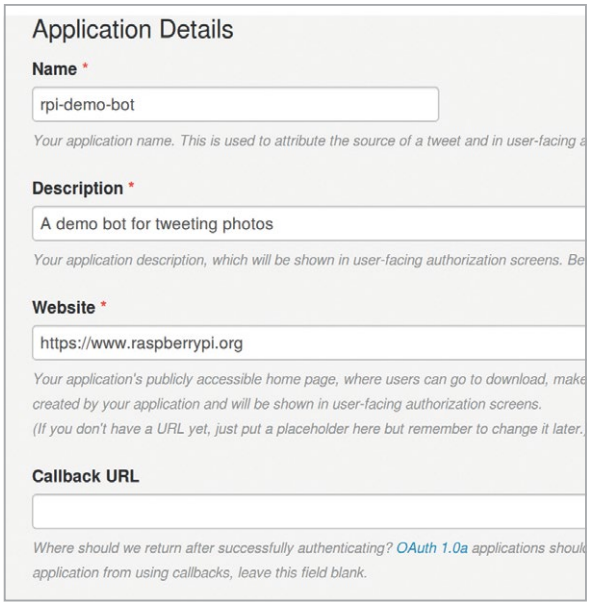
To achieve this, you'll need to make some changes to your script. You'll need to edit it so that each time the push-button is pressed, not only is the photo taken, but a random phrase is chosen from a list, and then the phrase and photo are sent to Twitter together.

To use the Twitter API with any programming language, you'll need to complete a few simple steps. First, register for a Twitter account, or log into yours.

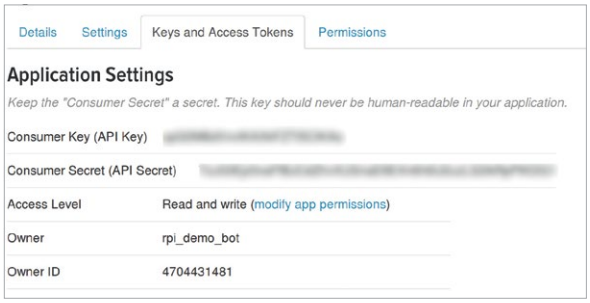
Next, you need to create a new Twitter application. This will allow you to authenticate the program you are about to write. Go to **apps.twitter.com** and then click the Create New App button.



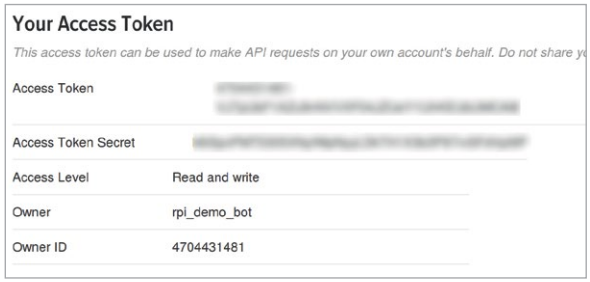
You'll need to fill in a few details about your app. Don't worry about the 'Website' field – you can place any URL here for now if you don't own your own domain. The 'Callback URL' can be left blank. Click on the Create Application button when you are done.


Application Details
Name *
rpi-demo-bot
Your application name. This is used to attribute the source of a tweet and in user-facing
Description *
A demo bot for tweeting photos
Your application description, which will be shown in user-facing authorization screens. Be
Website *
https://www.raspberrypi.org
Your application's publicly accessible home page, where users can go to download, make
created by your application and will be shown in user-facing authorization screens.
(If you don't have a URL yet, just put a placeholder here but remember to change it later.
Callback URL
Where should we return after successfully authenticating? OAuth 1.0a applications shoul
application from using callbacks, leave this field blank.

You will now have an app that you can use to access the API. Clicking on the 'Keys and Access Tokens' tab will reveal your authentication details for Twitter.



Next, you'll need to generate your access tokens by clicking on the 'Create my access token button' at the bottom of the screen.



All these keys, tokens, and secrets need to be kept secure. If you accidentally share them with someone, then you can regenerate them to get new random strings of characters.

Tweet with your credentials

The best way to store your credentials is to keep them on your computer as a JSON file. Open a text editor such as LeafPad, TextEdit, or Notepad. Create a new file and then add in your credentials in the following format (using the details for your app).

```
  {
      "consumer_key": "I40wL40inrt43Z71eeoir1662",
      "consumer_secret":
"ZwLwMeTuWIjA9v1aRJeJUxrSoBYbNxzrteSxiPl59mdbU7mS0b",
      "access_token":
"1841344074-R5b20nSAYEwYUxyfw87MWCGeHPwe5WREbPIyDjg",
      "access_token_secret":
"p4lRvFlaI5vGCjSCqvF1jCeTwx3BAAScJWutsQy8a2ZOFP"
  }
```

Save the file as **twitter_auth.json** in the same directory as your program. Now we can learn how to send tweets using the Python module called tweepy. If it's not already on your computer, then you can install it using pip from the Terminal:

```
sudo pip3 install tweepy
```

Open IDLE and create a new Python file. You could call it **tweeter.py**. Next, you'll need to import the modules required for authentication and sending a tweet. The tweepy module lets you interact with the Twitter API. The json module is used to read your authentication data.

```
import tweepy
import json
```

Next, you need to open the JSON file that contains your authentication data and read it all into your Python program. Make sure that your JSON file is in the same directory as the Python program you are writing.

```
with open('twitterauth.json') as file:
    secrets = json.load(file)
```

You can run your program now if you like. If you type **secrets** into the Shell pane, you'll see that your authentication details have been loaded into a Python dictionary. Now you need to provide your authentication details to the Twitter API. The following lines of code will load your details and prepare the API connection.

```
  auth = tweepy.
OAuthHandler(secrets['consumer_key'],
secrets['consumer_secret'])
  auth.set_access_token(secrets['access_
token'], secrets['access_token_secret'])
  twitter = tweepy.API(auth)
```

Lastly, you can send a tweet with a single line of code.

```
  twitter.update_status('My first
automated tweet!')
```

If you head on over to **Twitter.com** now, you should see that your tweet has been posted. If you want to send an image, then you can change the last line of code slightly.

```
  twitter.update_with_media('/path/to/
image.jpg', 'your status update')
```

Choosing a random phrase

There is a built-in module in the Python programming language called **random**. This module contains lots of useful methods for playing around with random numbers. One of its methods, called **choice**, allows the computer to choose a random item from a list.

If you want to use it, first import the **choice** method from the **random** library, and then create a list to use.

```
from random import choice
my_list = [1, 3, 5, 7, 9]
my_num = choice(my_list)
```

You can see what the value of the **my_num** variable is by typing its name into the Shell pane.

```
>>> my_num
3
>>>
```

Any data that you place inside a list can be selected with **choice()**. For instance, you might want to use strings:

```
from random import choice
greetings = ['Hello there', 'How are
you?', "What's up", 'Yo!']
my_greeting = choice(greetings)
```

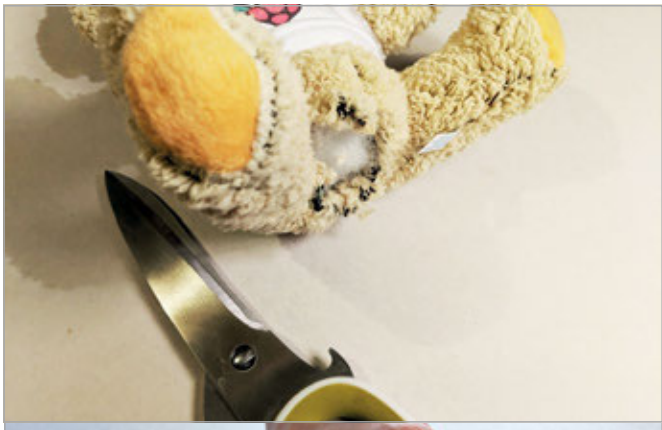
With all this, you should be able to make code that, with a press of a button, takes a photo and then tweets it. You may need to make the code pause between taking the photo and posting the tweet, though!

Installing the camera

Your final step is to integrate your tweeting bot into a cuddly toy. These images show the process with Babbage, the Raspberry Pi Foundation's mascot. You can use any cuddly toy you like, though.

Take your cuddly toy and make an incision in its rear end with scissors. Cut all the way across the bottom from the thighs, a little more than the width of the Raspberry Pi.

Remove as much stuffing from the body as possible. Remove it from the head, body, and right arm, but leave the left arm and both legs.

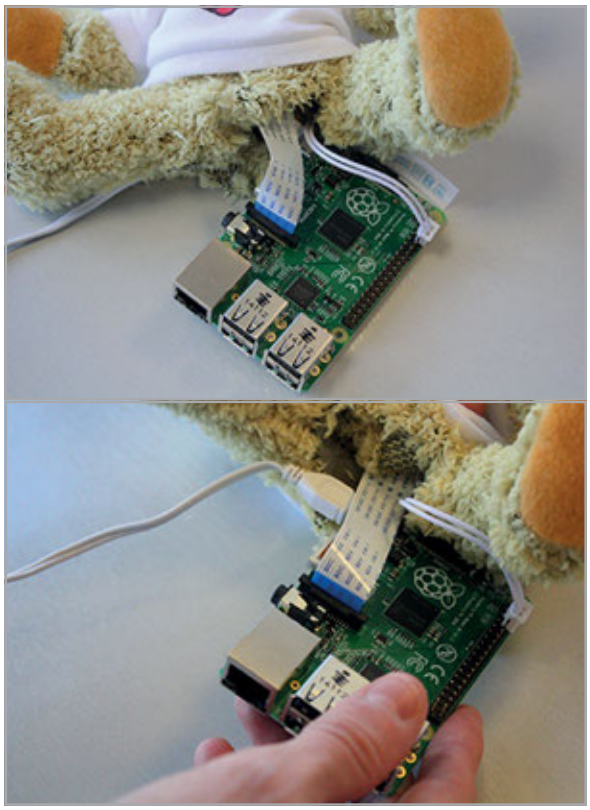


Insert the button into the cuddly toy with wires attached. Place the button inside the paw, and leave the wire trailing out. There's no need to have it attached to the Pi yet. Replace the arm stuffing to keep the button in place.

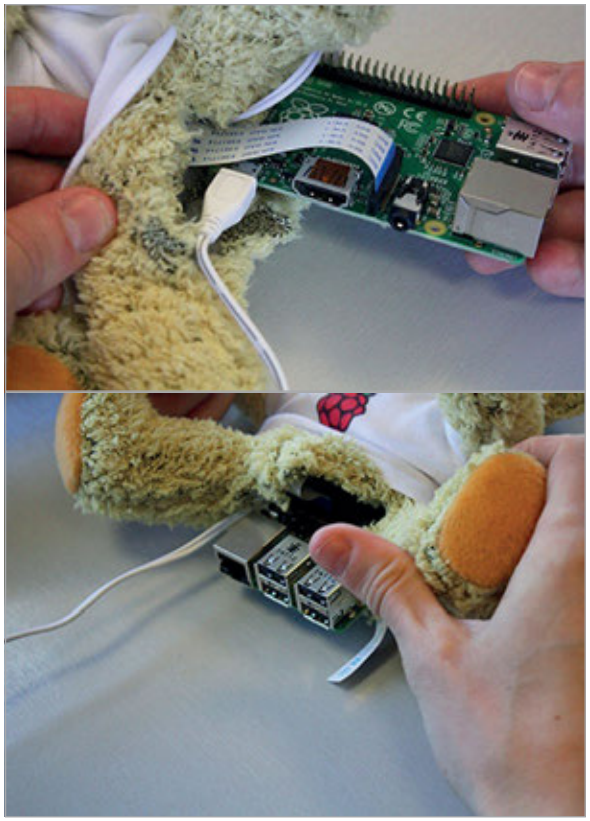
Now, cut out the right eye with scissors – take care, as it may be attached with something sharp! Try not to remove any fabric; just loosen the eye from the socket.

Insert the unattached Camera Module into the cuddly toy, carefully positioning the camera lens so that it is pointing out of the eye socket.

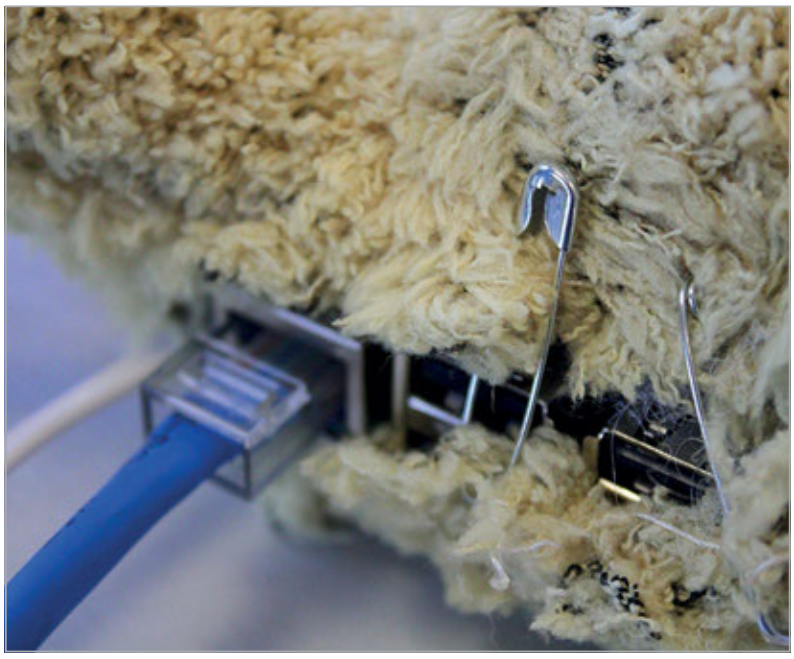
Replace the head stuffing behind the Camera Module to keep it in place. When ready, connect the Camera Module to the Raspberry Pi and wire up the push-button to the pins used earlier, GND and GPIO14. Now connect the Pi's power cable.



With the power cable, camera, and GPIO button connected to the Pi, carefully insert the Pi into the cuddly toy so that the USB ports face the bottom end.



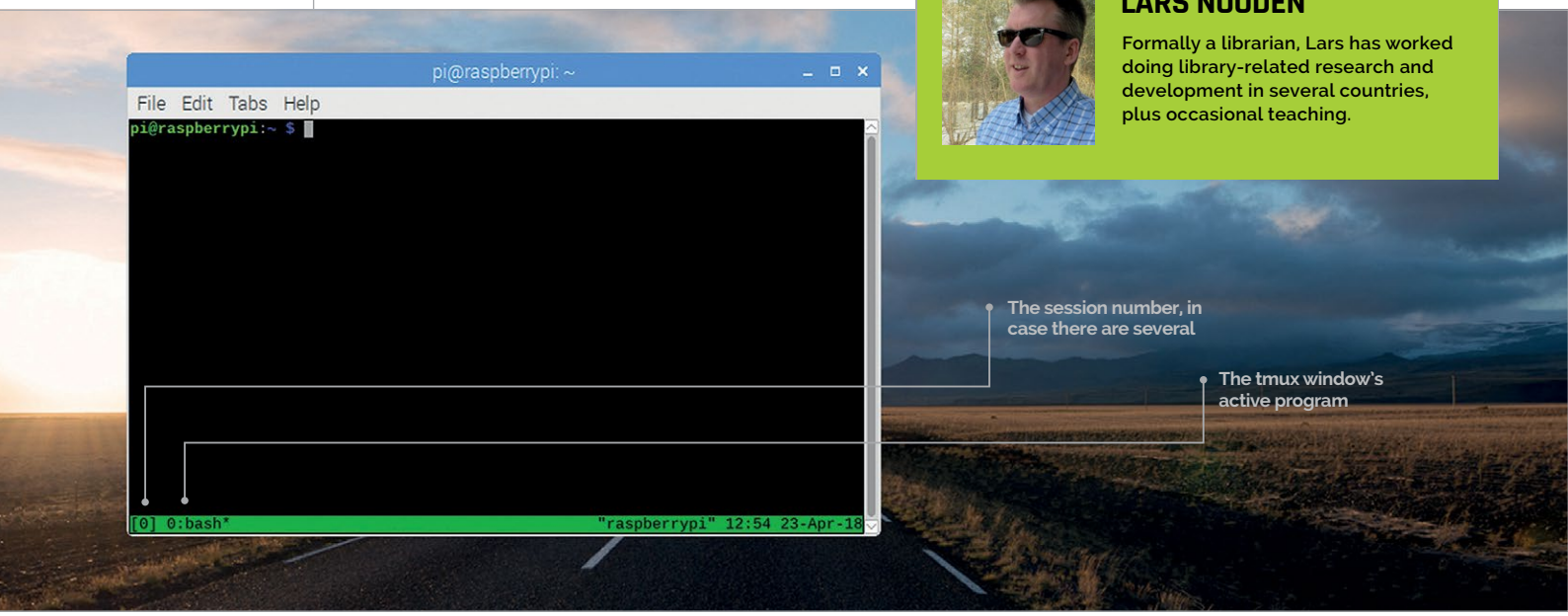
Replace the body stuffing to pad it out and use safety pins to close the incision over the USB ports.



Connect the Pi's power supply to a wall socket (or to a battery pack) and wait for it to boot. Once it's ready, every time you press the button in the paw, the Pi will take a picture and tweet it!

LARS NOODÉN

Formally a librarian, Lars has worked doing library-related research and development in several countries, plus occasional teaching.



You'll Need

- A Minetest or Minecraft server
- SSH connectivity to the server
- Access to install tmux there

MONITOR MINECRAFT SERVERS WITH TMUX

Connect, disconnect, and reconnect as often as you like to your remote server activities without losing anything when the terminal closes

With tmux, a popular terminal multiplexer, you don't have to lose any work when disconnecting from your Raspberry Pi in the terminal. In fact, if you close your terminal window, change network connections, or even close the lid on your laptop, tmux will keep running on the remote machine with your long-running programs inside it. None of these otherwise killer disconnections will interfere with the smooth running of your remote programs. They'll be able to keep chugging along without you until you get back to them at your convenience. Any long-running task will do, such as a Minetest server.

TMUX

A shortcut for `tmux new-session` is just plain `tmux`

>STEP-01

Installing tmux

If tmux is not already on the Raspberry Pi, now is the time to add it.

```
sudo apt-get update;
sudo apt-get install tmux;
```

That will provide both tmux and its manual page. Under the hood, tmux operates on a client-server model with each running as an independent process. The part you see is the client. The server is the part that stays running even when the client is disconnected. Customisations, such as key bindings or changing the status bar, take place in the configuration file, **~/.tmux.conf**, but for now we'll head straight into running tmux, starting with the basics.

>STEP-02

Starting an initial tmux session

Log in to your server host computer using SSH. At the regular shell prompt, before you do anything else, start a new tmux session:

```
tmux new-session;
```

While tmux is running, you'll see a status bar across the bottom of the terminal. Over on the right-hand side it will show the machine name, time, and date. On the left side, you'll see the tmux session number in brackets and next to that the number of the first tmux window and the active program name, such as the shell 'bash'. The asterisk means that particular tmux window is the one in view at the moment.

>STEP-03

Disconnecting from tmux

Start your game server there inside tmux, like you would in a normal shell. Once you have it running in tmux, disconnect by closing the terminal window. This closes your SSH session. Normally the remote processes would shut down when that happens. It will close the tmux client to be sure. However, your remote program is still running comfortably inside the server component of tmux and you can reconnect to it whenever you want, when you log in again with SSH and launch a tmux client.

>STEP-04

Reconnecting to tmux

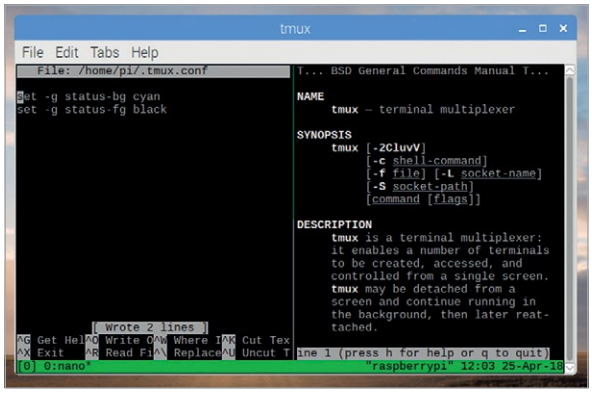
Log in again using SSH. At the regular shell prompt, optionally check for your existing tmux session:

```
tmux list-sessions;
```

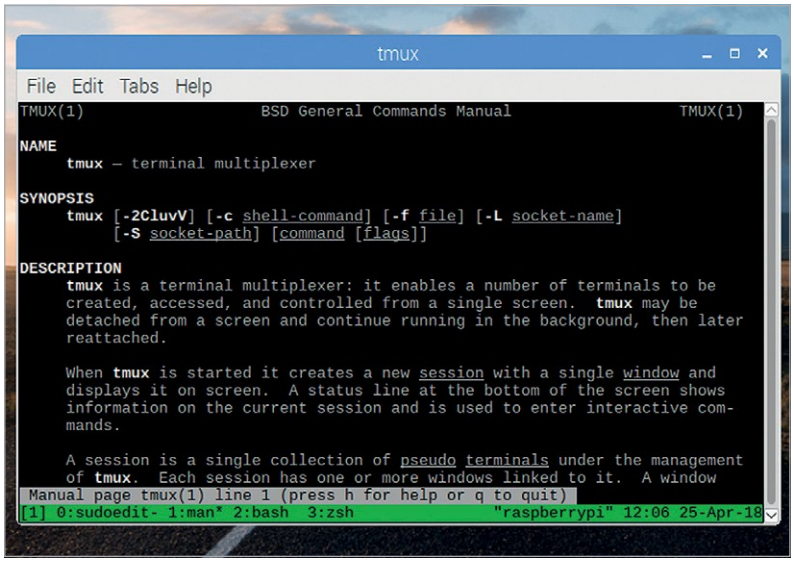
That will show your established session, when it was started, and how many tmux windows it may have running. However, whether you check first or not, reconnecting is easy.

```
tmux attach-session;
```

You'll find that tmux then rejoins your session progress. If things were active while you were gone, some new text might be there and the old text may have scrolled off the top of the screen.



Above CTRL+B+C creates new windows; CTRL+0, CTRL+1, and so on switches between them


tmux
File Edit Tabs Help
TMUX(1) BSD General Commands Manual TMUX(1)
NAME
tmux – terminal multiplexer
SYNOPSIS
tmux [-2CluvV] [-c shell-command] [-f file] [-L socket-name]
[-S socket-path] [command [flags]]
DESCRIPTION
tmux is a terminal multiplexer: it enables a number of terminals to be created, accessed, and controlled from a single screen. tmux may be detached from a screen and continue running in the background, then later reattached.
When tmux is started it creates a new session with a single window and displays it on screen. A status line at the bottom of the screen shows information on the current session and is used to enter interactive commands.
A session is a single collection of pseudo terminals under the management of tmux. Each session has one or more windows linked to it. A window
Manual page tmux(1) line 1 (press h for help or q to quit)
[1] 0:sudoedit- 1:man* 2:bash 3:zsh
"raspberrypi" 12:06 25-Apr-18

Above Split a window into panes with CTRL+%; switch between them with CTRL + right and CTRL + left

You can disconnect and reconnect as many times as you like: there are no limits there.

>STEP-05

Quitting tmux

Your tmux session ends when its last tmux window is closed. So quit what you had running inside tmux, whether it was your game server or another program, as normal. Then type **exit** at the shell prompt inside tmux to quit that tmux window. When the last tmux window has been closed, the tmux server to which it's connected will also quit. It will leave you in your regular shell, still logged in via SSH. If you want to be sure, then try listing the tmux sessions:

```
tmux list-sessions
```

...and that will let you know whether tmux is still there or not.

>STEP-06

Going further

Steps 1 through 5 were just the tip of the iceberg. The tmux reference manual covers much more and is well worth becoming familiar with, even if it's a bit daunting at first.

Over time it will become comfortable and you will have a fun, easy, and powerful tool with which to augment your terminal. So before you log out from SSH, check the reference manual briefly:

```
man tmux
```

Look up some extra options for **new-session**, **attach-session**, and **list-sessions** there. You'll get a good list of words and phrases to help find the many specialised tmux tutorials via your favourite search engine.

TMUX A

A shortcut for `tmux attach-session` is just plain `tmux a`

HAILEY R. FALK

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HARRY H. CHENG

Harry is a professor in the Department of Mechanical and Aerospace Engineering at UC Davis and the director of the UC Davis C-STEM Center.
cstem.ucdavis.edu

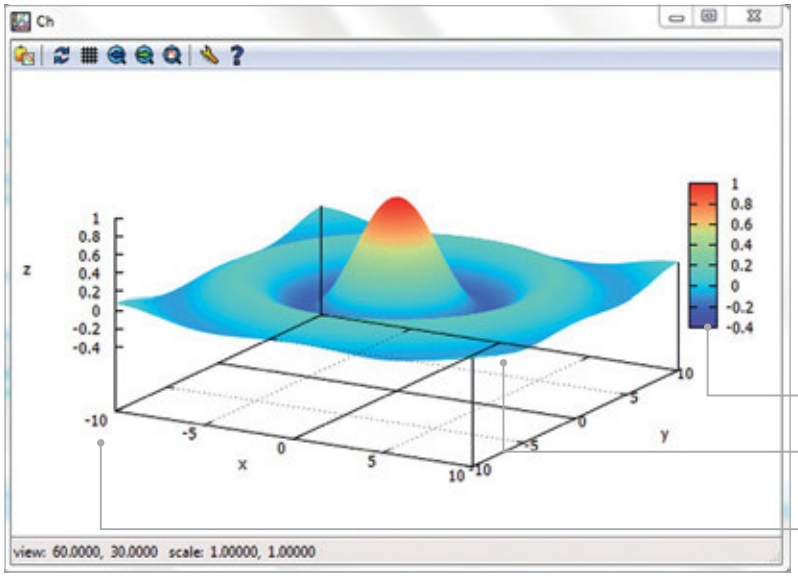


Figure 1
Personalise colours to represent trends in your graph

Ch allows you to visualise complicated functions in three dimensions with small amounts of code

Easily customise your graph with keys, titles, and labels for clear identification

EASY GRAPHICAL PLOTTING IN C/C++

You'll Need

- Raspberry Pi with C-STEMbian installed **magpi.cc/2p3JUNP**

Utilise data visualisation to better understand problems in maths, science, and engineering

As the saying goes, a picture is worth a thousand words. Graphical plotting is useful for visualisation and understanding many problems in maths, science, and engineering. In this article, we will learn how to write programs for graphical plotting.

A user-friendly integrated development environment, ChIDE provides the simplest possible solution for two- and three-dimensional graphical plotting within the framework of C/C++. It removes many of the hassles associated with programming in C by using the C/C++ interpreter, Ch.

Ch is a superset of C with many high-level extensions. It can run C code without compilation. All of the tools necessary to visualise data are available on C-STEMbian, a freely available operating system for Raspberry Pi.

C-STEMbian is a superset of Raspbian and includes several tools that provide a user-friendly environment for computing, robotics, and cyber-physical systems.

FIND ADDITIONAL RESOURCES

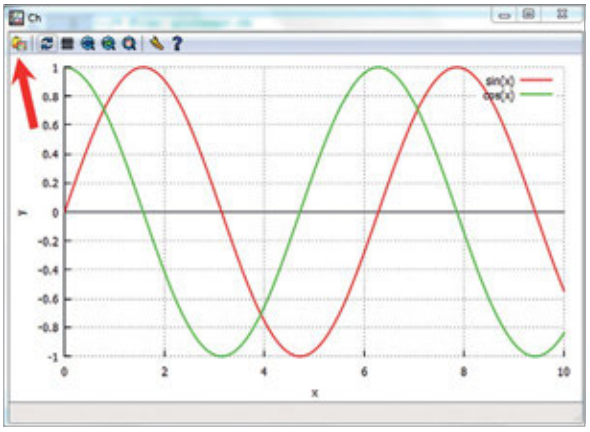
Check out the freely available programs and textbooks in the 'Code in Curriculum' section of C-STEM Studio for additional ideas and help.

Plotting expressions

Ch code allows you to quickly and easily produce a plot from any expression imaginable. In this program, **plotexpr.ch**, we will plot the sine function. The relation represented in a mathematical expression can be plotted by using the member function `plot.expr()` in the plotting class `CPlot`.

Saving a plot

Unlike in a graphing calculator, plots in Ch can be copied and pasted easily into other applications such as a Word file. In Windows, a displayed plot can be copied to the clipboard first, then pasted to other programs such as a Word document or PowerPoint, to print out or for a project report. Clicking the first



Above Copy your plot by clicking the first menu on the toolbar, as shown by the red arrow

Language
>CH

NAME:
plotexpr.ch, hatplot.ch, recorddistance.ch, drawcat.ch

DOWNLOAD:
magpi.cc/QBWVSJ

PERSONALISE GRAPHS

There are several member functions of the plotting class `CPlot` to create and manipulate plots. For example, with `plot.linestyle(".")`, it is simple to make a dotted-line plot and with `plot.legend("Graph Name")`, it is easy to create a legend for your plots.

menu on the toolbar on the upper left corner of the plot will copy the plot to the clipboard. The plot in the clipboard can then be pasted into other programs.

Plotting in 3D

Ch even allows for plotting in 3D. With small amounts of code, users can create elaborate graphs. For example, the graph of z = sin((x^2+y^2)^(1/2))/(x^2+y^2)^(1/2) is plotted in less than 20 lines of code in **hatplot.ch** (shown in **Figure 1**).

Personalising your graph

Plots in Ch can be designed with different line colours, styles, and widths. Use the following member functions to customise a plot:

`plot.lineStyle("style")`

Input style `"-"` for a dashed line or `"."` for a dotted line

`plot.pointStyle("style")`

For scatter plots, input styles such as `"x"` for cross-shaped points or alternatively `"d"` for diamond-shaped points

`plot.strokeColor("color")`

Input colours such as `"red"` or `"purple"`

`plot.strokeWidth(width)`

Input a number of pixels, such as `"2"` or `"5"` to set the width of a line

`plot.fillColor("color")`

Input a colour name or RGB value to fill the interior of plotted shapes

`plot.fillOpacity("color")`

Input a decimal to set the opacity of filled shapes. When the opacity is 0, the object is completely transparent; when it's 1, the filled colour is solid

Using these functions and those to plot different shapes, such as **`plot.circle`**, **`plot.triangle`**, and

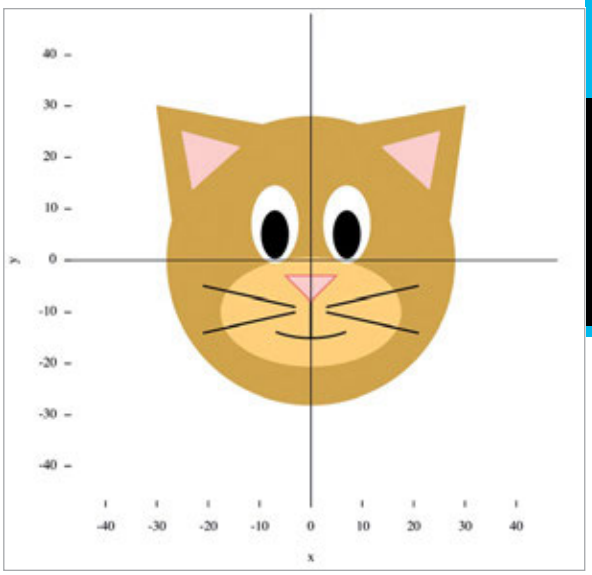
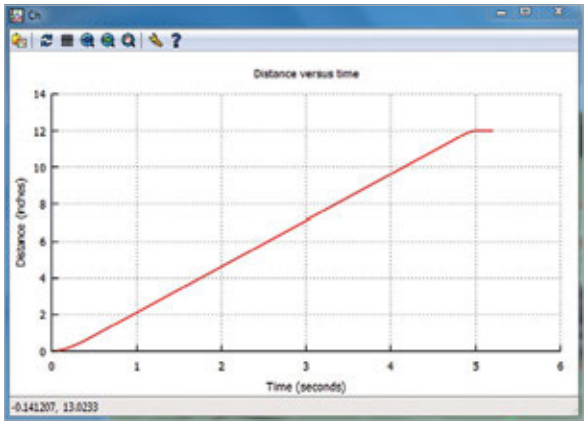


Figure 2 Create unique drawings with Ch code

`plot.arc`, it is easy to create unique drawings with Ch code. For example, easily draw a cat with multiple colours and shapes in **drawcat.ch** (see **Figure 2**).

Plotting motion of a robot

With C-STEM Studio, it is simple to write a program to receive data from hardware, such as a Mindstorms NXT/EV3 robot, in real time. The ability to record and process real-time data is a powerful tool with multiple applications in robotics. It aids in the understanding of how a robot is functioning so that we can improve upon that robot's design. In the next program, **recorddistance.ch**, we will plot the distance values of robot travelled versus time with real-time data. Configure your Mindstorms to the Vehicle Configuration, connect to the robot, and run the program.



Above Observe the performance of hardware using real-time data

ChIDE provides endless opportunities for data visualisation. With the simplicity of Ch, the ability to create spectacular plots in only a couple of lines of code is completely possible. To explore more of ChIDE and the customisation options to visualise data on ChIDE, download C-STEMbian to your Raspberry Pi.

BRIAN BEUKEN

Very old game programmer now teaching very young game programmers a lot of bad habits at Breda University of Applied Science in Breda NL.
scratchpadgames.net

CODING GAMES ON THE RASPBERRY PI IN C/C++ PART 06

This month, we look at how we can speed up our game

You'll Need

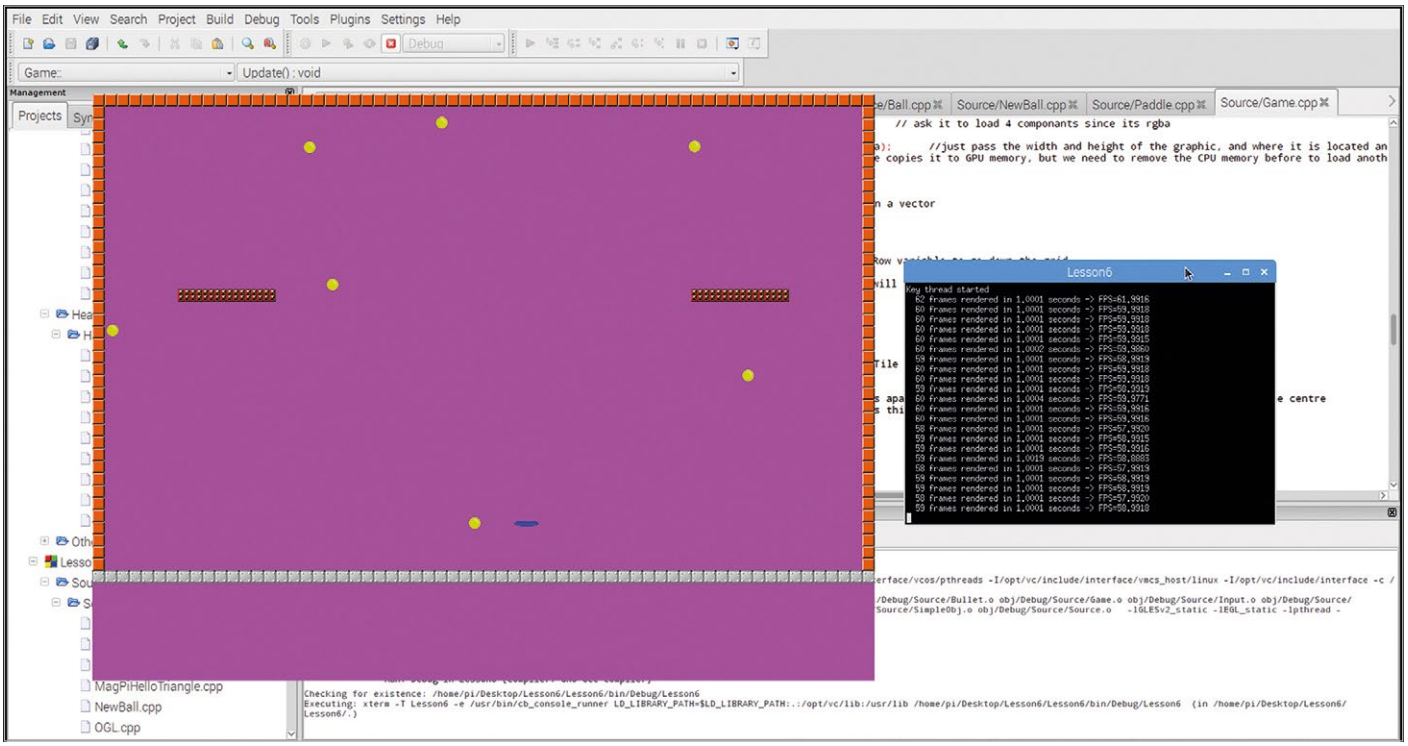
- Code::Blocks
  `sudo apt-get install codeblocks`

The basic game we have so far is fine. We have a simple game framework where we express our class concepts as derived versions of a useful base class. This is a design pattern commonly known as 'flyweight'; it's considered a good basic system for simple games, as we are doing now.

But our game is slow. If we put a frame counter on it, we will find it actually is running at something around 20 frames per second (fps). Also, our key reading system is pretty terrible, and we can't move and shoot at the same time. The key reader we can certainly fix with a better system, which we will get to soon.

But first, why is it slow? We're only moving a bat, a few balls, and some bullets. There's not a lot of computation needed; we've seen our Raspberry do much more work than that.

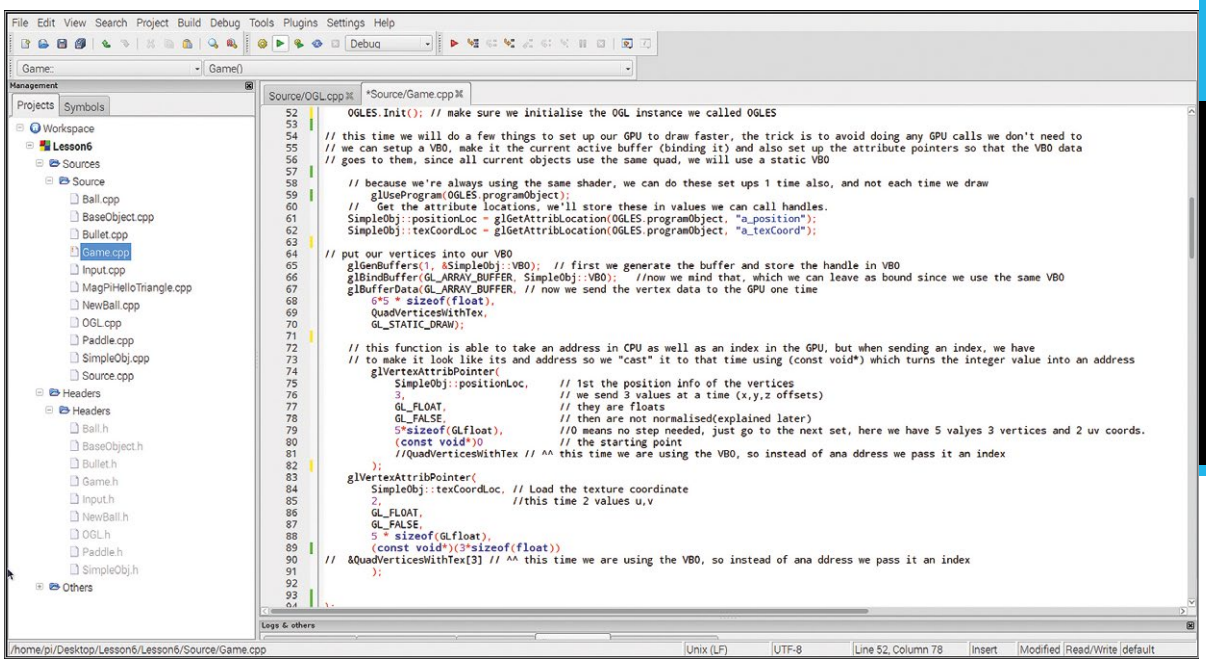
Well, it's true we are only moving a few things, but the reality is we're drawing every single tile on



Language
>C++

NAME:
MagPiHelloTriangle.cpp
SimpleObj.h/cpp
Game.h/cpp
OGL.h/cpp
Ball.h/cpp
NewBall.h/cpp
Paddle.h/cpp
Input.h/cpp

DOWNLOAD:
magpi.cc/SowxSL


File Edit View Search Project Build Debug Tools Plugins Settings Help
Debug
Game::
Game()
Management
Projects
Symbols
Workspace
Lesson6
Sources
Source
Ball.cpp
BaseObject.cpp
Bullet.cpp
Game.cpp
Input.cpp
MagPiHelloTriangle.cpp
NewBall.cpp
OGL.cpp
Paddle.cpp
SimpleObj.cpp
Source.cpp
Headers
Headers
Ball.h
BaseObject.h
Bullet.h
Game.h
Input.h
NewBall.h
OGL.h
Paddle.h
SimpleObj.h
Others
Source/OGL.cpp
*Source/Game.cpp
OGLES.Init(); // make sure we initialise the OGL instance we called OGLES
// this time we will do a few things to set up our GPU to draw faster, the trick is to avoid doing any GPU calls we don't need to
// we can setup a VBO, make it the current active buffer (binding it) and also set up the attribute pointers so that the VBO data
// goes to them, since all current objects use the same quad, we will use a static VBO
// because we're always using the same shader, we can do these set ups 1 time also, and not each time we draw
glUseProgram(OGLES.programObject);
// Get the attribute locations, we'll store these in values we can call handles.
SimpleObj::positionLoc = glGetAttribLocation(OGLES.programObject, "a_position");
SimpleObj::texCoordLoc = glGetAttribLocation(OGLES.programObject, "a_texCoord");
// put our vertices into our VBO
glGenBuffers(1, &SimpleObj::VBO); // first we generate the buffer and store the handle in VBO
glBindBuffer(GL_ARRAY_BUFFER, SimpleObj::VBO); //now we mind that, which we can leave as bound since we use the same VBO
glBufferData(GL_ARRAY_BUFFER, // now we send the vertex data to the GPU one time
6*5 * sizeof(float),
QuadVerticesWithTex,
GL_STATIC_DRAW);
// this function is able to take an address in CPU as well as an index in the GPU, but when sending an index, we have
// to make it look like its and address so we "cast" it to that time using (const void*) which turns the integer value into an address
glVertexAttribPointer(
SimpleObj::positionLoc, // 1st the position info of the vertices
3, // we send 3 values at a time (x,y,z offsets)
GL_FLOAT, // they are floats
GL_FALSE, // then are not normalised(explained later)
5*sizeof(GLfloat), //0 means no step needed, just go to the next set, here we have 5 valyes 3 vertices and 2 uv coords.
(const void*)0 // the starting point
//QuadVerticesWithTex // ^^ this time we are using the VBO, so instead of ana ddress we pass it an index
);
glVertexAttribPointer(
SimpleObj::texCoordLoc, // Load the texture coordinate
2, //this time 2 values u,v
GL_FLOAT,
GL_FALSE,
5 * sizeof(GLfloat),
(const void*)(3*sizeof(float))
// &QuadVerticesWithTex[3] // ^^ this time we are using the VBO, so instead of ana ddress we pass it an index
);
Logs & others
/home/pi/Desktop/Lesson6/Lesson6/Source/Game.cpp
Unix (LF)
UTF-8
Line 52, Column 78
Insert
Modified
Read/Write
default

Left
Making a VBO (best to look in the code)

screen and every single sprite individually. But we have a dedicated GPU; it's very fast, so it can't be the problem?

Well, again, that's true, but the way we use the GPU is something we have to consider and it's important we do that now so we can avoid this speed issue in future.

Making best use of a GPU

Our GPU is a fantastically cool thing: it is a specialised processing unit which can do dozens of complex calculations before our CPU could even do one. But the GPU operates in its own little pool of memory which the CPU does not have access to. That's why we split 1GB of memory between the CPU and the GPU.

Once it's allocated, the GPU cannot directly talk to the CPU's memory and vice versa. And therein lies our problem. We store all our data for cubes and position in our CPU side, and have to somehow tell the GPU to do the draw.

Now, there is a way the GPU can get access to that data, but it involves a slow internal transfer system which can only send a few bytes of data at a time. This results in what's known as a bottleneck, where a lot of data is trying to push through a very narrow space to get out.

So what can we do about it? Well, in some ways nothing: the time it takes to send data to the GPU is not going to change, but we can do something about how often we send it. At the moment, we send it every single game cycle, for maybe 100 objects, so the bottleneck occurs 100 times during our gameplay.

The GPU, however, can store data it has in buffers that it can keep control of, and once the data is in those buffers it means that the GPU has the data in its own memory space, and that is a lot faster.

All of our current tiles and sprites are variations on a set of vertices that form a quad or square, so why not send a set of quad vertices over to the GPU, store them in a buffer, and reuse that buffer over and over again?

Let's do that, then. The buffers we need to make are called VBOs (vertex buffer objects) and can be any data we choose, so long as we make sure we have a repeating pattern of data. So in our case, our repeating pattern is a three-float value (x, y, and z=0) and two uv texture co-ordinates.

Since we only want to send this once, we will make it part of our initialize **`Game`** class process. When we make the VBO, OpenGL ES 2.0 will give us an identifying value, or handle, that will relate to that buffer. We only plan to use one VBO in this game, so once we set it up we can leave it active, bound to the GPU so that is the only VBO it uses. There are ways to improve this further using indexing and instance concepts, but for now this will give us the boost we need.

Later, when we want to have more shapes and shaders, we will need to give individual objects more responsibility for their ownership of different shaders and VBOs.

We've shuffled a few things around in the code, but now you can see our **`Game`** init is handling most of the GPU questioning and setting up, leaving the **`SimpleObj Draw`** method to just, draw!

There is still a need to send positional and scale data to our GPU so the shaders can work, and that also is a bit of a bottleneck, but some things can't be avoided. However, with these simple changes and removing the repeating test for an error, we can more than double the speed of the game.

Did you see the warning signs?

Finally, let's consider the code itself. There are a lot of small issues with it which we've hidden from you by asking the compiler to not list warnings. If you go into Build Options > Compiler Settings > Compiler Flags,

CHECK THE WARNINGS

Warnings are useful to see, but sometimes we allow a warning to stay as a reminder. Be careful not to let too many warnings build up.

CLASSES SHOULD BE SIMPLE

A small self-contained class can be plugged into every game you work on.

you can untick 'Inhibit all warnings' and rebuild the lesson code. It does not look pretty! (See **Figure 1**.)

So what are these warnings, and why should we care? The code is working! Let's just leave the ignore mode on? Well we can, but warnings really are important, because it's the compiler telling us we might have made a mistake, and then the compiler doing its best to fix it. Most of the time that will be OK, but sometimes it won't.

In this case the warnings are very easy to fix and mostly relate to our use of inherited classes, and the need to keep memory tidy.

When we create a class, we have two special methods that are responsible for memory management in the instance of that class: the constructor and its opposite, the destructor, which is responsible for cleaning up the class when it is deleted.

It's perfectly possible for both these methods to be empty, but if at some point you create a new instance of any other class or allocate memory, during an instance's lifetime, you will need some way to remove it. Every **new** must have a **delete**, and **delete** is directly related to the use of the destructor. The destructor's job is simply to make sure any memory the class used up with **new** (or other allocation methods) is released, so that the instance is removed with no footprint left on the memory.

> "Things get a little complex if we have a class which inherits or derives from a base class"

That's all pretty easy to get our heads around – **new** will call a constructor, **delete** will call a destructor – but things get a little complex if we have a class which inherits or derives from a base class.

When we delete an object from its base pointer, we call the destructor for that base class, which is probably OK, but suppose the constructor for the derived class did some **new**s…Well, that class's destructor should have taken care of that, but it never got called because we had the instance declared as its base type.

Of course, you may not have created anything in that class, but the compiler doesn't know, so the compiler warns us that we might have forgotten this.

We can solve this simply, by telling the base class that its destructor is a **virtual** method; that means that any classes which inherit it, and have their own destructor, will override the base destructor and it will be that later class destructor that gets called.

Problem solved: adding **virtual** to the base class destructor removes those warnings on the next compile and prevents a very serious error which would not be obvious if we did create new objects in the derived classes.

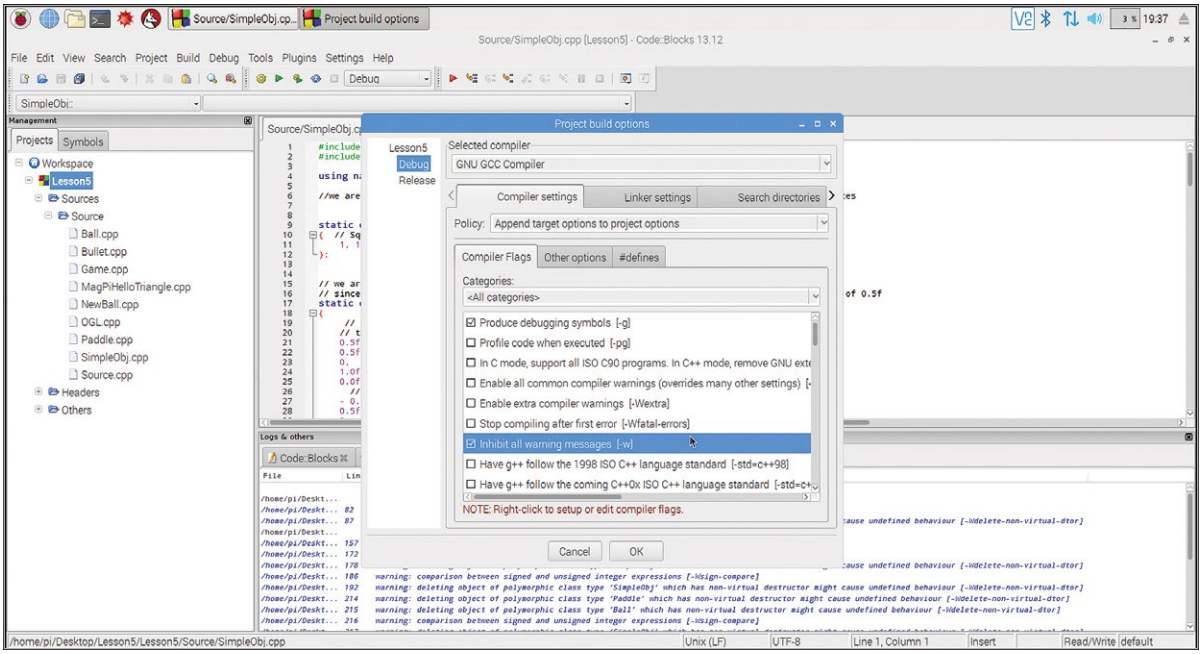
The other warnings relate to confusion over types, so we can clarify those by clicking on the warnings and changing **int** to **uint** (**Figure 2**). Some warnings we might leave; the unused **Dummy** in **stbi.h**, for example. We didn't write that, so best not to mess with it, but you can review the unused **ypos** and see if perhaps you need to remove it.

Now, warnings won't stop your project running, but if when it is running, you get odd things happening, those warnings may very well be the reason. So as far as you can, remove warnings as soon as possible.

Things can only get better

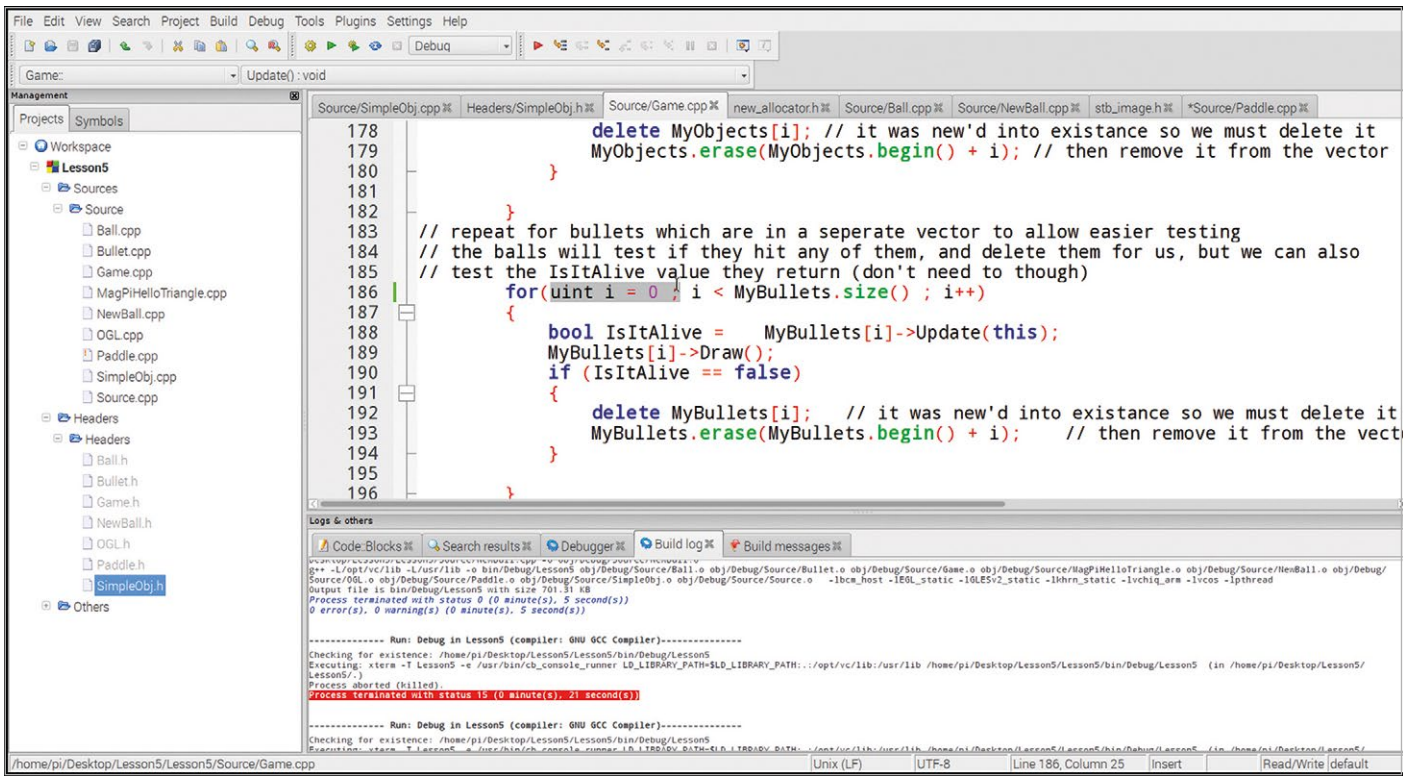
Now that's all looking a bit tidier. We have code that compiles and runs cleanly, screen updates that are much faster, and time to deal with this key read which just isn't going to work for us.

Figure 1 Let's see the warnings



NEVER OPTIMISE AS YOU WRITE

Early optimisation nearly always ends badly. Write the code first, then make it better.



We can do this with a special key read system we have supplied. This is a pretty solid system which is designed to test the key being pressed, not the character it returns; that means it can test multiple keys at once.

One of the great advantages of C++ is that classes are usually designed to be self-contained: they may need to include some of the standard library functions (STL), but for the most part a class is designed to be plug and play.

The system comes as two files called **input.cpp** and **input.h**. Take a look at the latter and you will see that there is the usual constructor and destructor, and importantly an init method – not all classes init using their constructors.

We've included the files, and added the .h file to the **paddle** class and changed the constructor and update to use it – we don't need to remove the previous code because that has the nice feature of redirecting the OS key outputs that would go to screen when keys are pressed.

Now we have a ~60fps game, with a key system that does not stop when we try to print to the console and which allows us to press fire and move at the same time.

We should also provide our player (you) with the option to escape from the game, and ideally to a menu system. For that though we'll need a text display, so we will do that next time. For now, a simple escape sequence testing the **ESC** key will let us work out when our game is over, and we can finally use that bool value we've always set as true to indicate if the update on the paddle/bat returns false. If so, we will shut down the game.

There are still a few other small issues. Our collision detection isn't spot on, and we can only actually detect the hit itself, not where on the bat it hits – we need to do a bit more maths for that; can you try that yourself? Also, there are occasions where we can sometimes get a double hit, where the ball has detected the hit, changed direction but is still in a collision position – a simple fix for that is to put a small timer after the hit which does not allow another test. We should make that a part of the ball's collision test, and you can see we've added a small debounce test.

Figure 2 Change `int` to `uint` to be sure

Why now?

Now, a good question to ask is why did we not optimise our code when we started? In time, as you get better at coding, these fairly obvious features will become second nature. But it's far more important as a beginner just to get code working and then have a look at ways to make it better. Early optimisation can be a major problem for beginners, who need to focus mostly on the solution to the problem they have to solve.

Next time, we will adapt our code to make a more interesting arcade style, add text, and make a game with a character and animations.

KEEP BACKUPS

Use a source control system, so you have working fallbacks to use.

LEARN TO CODE WITH C

Enjoying using C and C++ and can't wait until next month for more? Check out our Essentials book, *Learn to Code with C*, for more C tutorials for beginners: **magpi.cc/learn-c-book**

FREQUENTLY ASKED QUESTIONS

NEED A PROBLEM SOLVED?

Email **magpi@raspberrypi.org** or find us on **raspberrypi.org/forums** to feature in a future issue.

Your technical hardware and software problems solved...

USB

WHAT USB PORTS ARE ON THE RASPBERRY PI?

Full-size Raspberry Pis

Raspberry Pi boards like the Model A+, Model B+, 2, 3, and 3B+ have USB 2.0 ports. The Model A+ only has one, while all the others have four. You can connect just about any device to a Raspberry Pi via the port, as long as the software or driver for it is available for Raspbian.

Raspberry Pi Zero

The Raspberry Pi Zero includes a single micro USB 2.0 port for data. You'll need to add a micro USB B to USB A converter to connect other devices, and you can find micro USB to USB hub devices that work well with the Pi Zero.

USB power

All versions of the Raspberry Pi include a micro USB port to power the Pi, similar to most common phone chargers. For most Raspberry Pi boards, 2A is recommended to power it properly, whereas the 3B+ works best with a 2.5A power supply.

HOW POWERFUL ARE THE USB PORTS?

Not so powerful

Raspberry Pi boards run on a fairly limited power supply, as discussed previously. The more devices you connect to the USB ports, CSI ports, GPIO, wireless, etc., the more power is consumed. In general, though, you won't be able to, say, run another Raspberry Pi off the USB ports, or a big external hard drive either. Some USB hubs will even require external power.

Power and speed

The USB ports on the Raspberry Pi are USB 2.0, which means they have a theoretical bandwidth limit of 480Mbps. In practice, you'll get anywhere between 280 and 350Mbps, which is also why the Ethernet port cannot truly run at gigabit speeds on the current Raspberry Pi models.

USB add-ons

Some add-ons, such as HATs, will increase the amount of USB ports on a Raspberry Pi. They may even require additional power to operate. Check the documentation for the USB add-on for how much power it outputs and any recommendations on what you can and cannot power via the ports.

WHAT ABOUT?...

USB C/3.0

Raspberry Pi boards do not have any support for USB 3.0 or USB C outside of generic compatibility with USB 2.0. For instance, a USB A-to-C cable will work, and so will USB 3.0 rated cables; however, the Pi will only supply the usual 2.0 power and speeds to the device.

Powering without USB

Raspberry Pi boards can be powered via the GPIO pins, specifically connecting 5V to a 5V pin and a ground cable to a ground pin. While it's not enough power to be truly dangerous, make sure you're careful when handling power of any kind, and refer to tutorials before attempting it.

Adding more USB ports

As mentioned before, there are several add-ons you can get for the Raspberry Pi that increase the number of USB ports – whether it's as simple as a USB hub or a full-on HAT, you'll be able to expand the USB ports in some way.

FROM THE RASPBERRY PI FAQ RASPBERRYPI.ORG/HELP

WHAT DISPLAYS CAN I USE?

There are composite and HDMI out ports on a full-size Raspberry Pi board, so you can hook it up to an old analogue TV through the composite or through a composite to SCART connector, to a digital TV, or to a DVI monitor (using a cheap, passive HDMI to DVI cable for the DVI). For the Model B+, Pi 2, and Pi 3, the RCA composite jack has been replaced with a 3.5 mm jack that combines audio and video in one. You'll need a 3.5 mm to 3RCA adapter cable to connect it to an older TV. There are many different types of this cable out there, but you want to purchase one that is compatible with the iPod Video (the iPod will have the left and right audio channels reversed, but the version of Raspbian included with NOOBS can swap this for you). The Pi Zero uses a mini-HDMI port.

There is no VGA support, but active adapters are available. Passive HDMI to VGA cables will not work with the Raspberry Pi. When purchasing an active VGA adapter, make sure it comes with an external power supply. HDMI to VGA adapters without an external power supply often fail to work.

DOES THE HDMI PORT SUPPORT CEC?

Yes, the HDMI port on the Raspberry Pi supports the CEC Standard. CEC may be called something else by your TV's manufacturer; check the Wikipedia entry on CEC for more information: **magpi.cc/xDtohp**.

WHY IS THERE NO VGA SUPPORT?

The chip we use supports HDMI and composite outputs, but does not support VGA. VGA is considered to be an end-of-life technology, so supporting it doesn't fit with our plans at the moment. However, if you really want to use a VGA monitor with a Raspberry Pi then it is possible using an HDMI to VGA adapter.

CAN I ADD A TOUCHSCREEN?

The Raspberry Pi Foundation provides a 7-inch capacitive touchscreen that utilises the Raspberry Pi's DSI port. This is available through the usual distributors. Alternatively, several third-party retailers offer a range of touchscreens for the Raspberry Pi.

WHAT CODECS CAN IT PLAY?

The Raspberry Pi can encode (record) and decode (play) H.264 (MP4/MKV) out of the box. There are also two additional codecs you can purchase through our Swag Store that enable you to decode MPEG-2, a very popular and widely used format to encode DVDs, video camera recordings, TV, and many others; and VC-1, a Microsoft format found in Blu-ray discs, Windows Media, Slingbox, and HD-DVDs.

THE MAGPI APP

Having trouble with The MagPi on the App Store or Google Play? Here are your most common questions answered.

How do I find The MagPi on Google Play or the App Store?
All you have to do is go to the search bar and type 'The MagPi' or 'Raspberry Pi' to find us.

I've subscribed to the digital edition and I can't sign in to restore my purchases. Please help!
Since your The MagPi purchases are linked to your Google or Apple accounts, there's no need to sign in at all. If you'd like to re-download your purchases on your current device, or make your purchases available on other devices, all you need to do is hit Menu on the home screen, then Restore Purchases on the side bar.

How can I search the digital magazine for keywords?
Finding direct references is really easy with The MagPi app – all you have to do is tap the screen to get the app's GUI to show, and then press the small magnifying glass icon in the top-right corner of the screen. Now, just type in your search term to find the relevant results.

GET IT ON Google Play

Available on the App Store

Upcycling WITH RASPBERRY PI

GIVE OLD TECH NEW LIFE WITH A RASPBERRY PI

Health & Safety Warning!

Electricity is dangerous. Electricity can kill or severely injure people and cause damage to property. Perform a health and safety risk assessment before working on electrical equipment to ensure that the equipment is safe and you feel competent to work on it.
See **hse.gov.uk/electricity** and **magpi.cc/NqUMcT**.

Hacking electronics with a Raspberry Pi is something we see every day. The diminutive size of the Raspberry Pi, and especially the Pi Zero, enables you to slip it into the smallest spaces and rewards you with a greater control over your modified project.

While hacking new tech is great, hacking old tech gets you even better results. Bringing 1970s and 1980s hardware to the 21st century is a great way to flex your maker muscles while also having something truly cool to show for your efforts.

We've got in touch with upcycler extraordinaire Martin Mander to help you get started making some retro-tastic projects.

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63 Switch & Control Tips
64 Upcycled Superstars

More from Martin

Keep an eye on Martin's Twitter page for his future projects:

twitter.com/OldTechNewSpec

Tools of the Trade

WHAT YOU'LL NEED TO UPGRADE OLD-SCHOOL HARDWARE

Making with a Raspberry Pi is similar across any decade. When it comes to specifically modifying old cases and repurposing ancient PCBs, however, there are a few tools you should be sure to have to hand, to make the process a little easier.

Rotary tool

Useful for making and maker-adjacent hobbies, a good Dremel or the like can help you prepare cases for their new electronics. Whether you're using the small cutting parts to hack away now unnecessary mounting points, or the gentler sanding parts to smooth parts out, you'll get a lot of use out of one.

Martin's Tip

"A drill press stand is even more useful, as it makes accurate drilling and sanding much easier."

LEGO and Meccano: various bits

You can use construction sets to build up braces and larger spaces inside cases to fit smaller electronics into. It's an easy way to pad out the inside of a case that you can quickly modify to suit your needs.

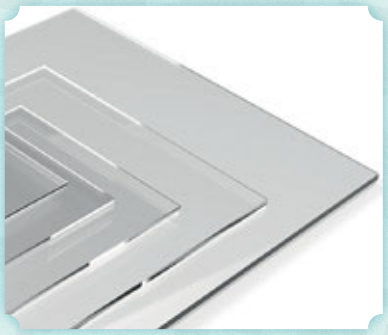
Image credit: Alan Chia

Martin's Tip

"It always feels a bit wrong to drill or hot-glue LEGO, but it and Meccano make brilliant semi-permanent structures to build around or hold components in place."

Sheet plastic and/or Perspex

A step above the 'semi-permanent' LEGO or Meccano, you can use plastic sheets to mount electronics. This helps keep your build tidy and a bit more sturdy if you have the room for it, and apparently helps with airflow.



Martin's Tip

"If you use clear Perspex, you can still see what's underneath, and it makes it simple to accurately mark out where you may need to drill holes."

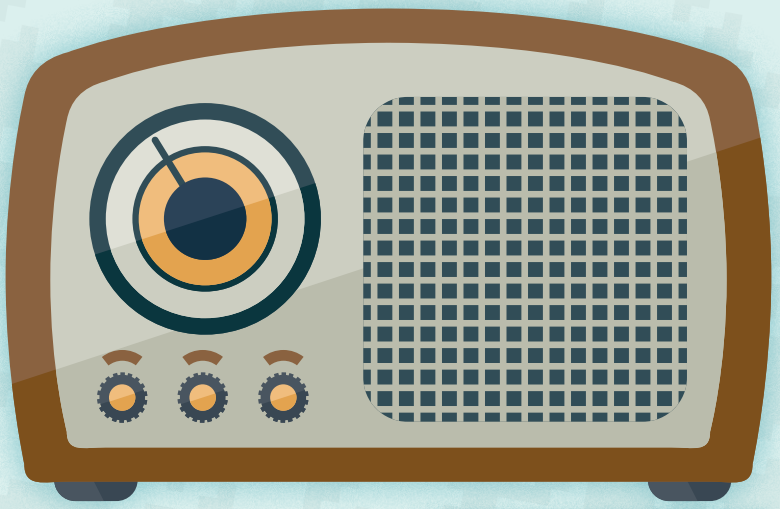
Multimeter, breadboard, and labels

If you want to reuse parts from the original device, you'll first have to know how they work. Sometimes you'll be able to figure it out by eye, but for those other times you'll have to do a bit of trial-and-error

OTHER USEFUL TOOLS

- Drill
- Soldering iron
- Wires
- Wire stripper
- Hobby knife
- Blu-tack
- Helping hands
- Lots of nuts, bolts, and washers

Image credit: Figuegl



using a multimeter; label it up so you don't forget, and then test it all out on a breadboard before committing to the build.

Martin's Tip

"If there are a lot of cables and the layout is a bit cryptic, it's easiest to plug them all into a breadboard, set up a basic LED circuit with a battery, and then use jumper cables to test all of the different combinations until you have it mapped out. However you get to the final 'Eureka' moment, it's critical to label the loose cables straight away, or write down what each one means if you're lucky enough for them to be colour-coded."

Magnetic parts tray

Once while taking apart a toy sword, we put all the tiny little screws in a small bowl. Which we then gave a good whack while working on the innards. After we managed to find all the screws an hour later, we decided to invest in a magnetic tray.

Martin's Tip

"It's always worth keeping all of the original screws and fittings to one side when tearing down old tech, as these can often be reused in the final build."

FURTHER RESOURCES

eBay

Need spare parts or a particular retro product to hack? Having a look on eBay is always a good first step

Company websites

It's always worth checking any websites for a company still in business in case they have some archived info on the product you're working on

Specialist forums

If you're tweaking a much-loved device from yesteryear, chances are there will be a forum you can go to for questions and expert advice. Practise your Google Fu to find one!

Raspberry Pi forums

While you may not be able to get help with your specific hardware, you should be able to find help for the Raspberry Pi component of your project on the official forum: **raspberrypi.org/forums**

MARTIN'S SWITCH AND CONTROL TIPS

In some cases, the original controls are too bulky or just won't work well with the Raspberry Pi, so using nice modern components is the best option. Even so, it's still possible to retain the tactile vintage feel of the original while keeping the wiring and coding as simple as possible.

Push Switches

Often an older piece will have a 'locking' switch for its on/off button, usually bulky because originally it handled mains voltage. If you need to replace one of these with a Pi-connected button, it's pretty straightforward: you can use a standard momentary push switch. A top tip, though, is to be careful to keep hold of the original button/knob spindles when dismantling – later you can snip these off the old switch and hot-glue the spindle to your new push-button, then the old knob will be a nice easy fit!

Rotary Switches

These are commonly found on old TVs and radios, where you'd turn a dial to change channels or adjust tuning. If you want to use this kind of control in your project then a great option is to use a 12-pole, single-throw rotary switch. If you wire up alternate poles to a single 3.3V GPIO pin, that leaves you with six that can either be connected to different GPIOs to perform multiple functions. Or, if you just need straight on/off or a momentary 'press' then you can wire all six poles to a single GPIO pin.

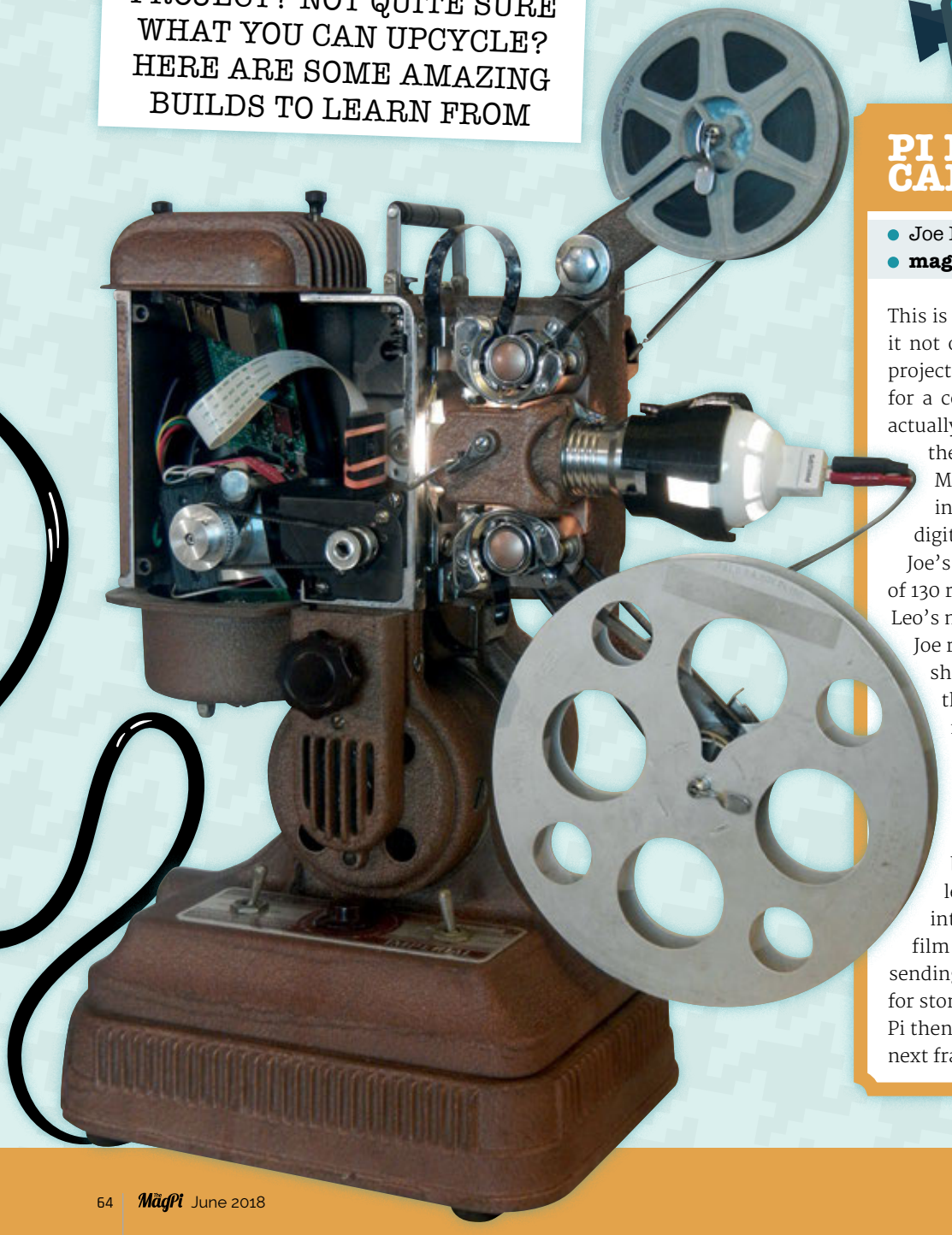
Turning the dial will then switch between closed and open states, keeping that retro feel but allowing you to code the switches in GPIO to suit your project's needs.

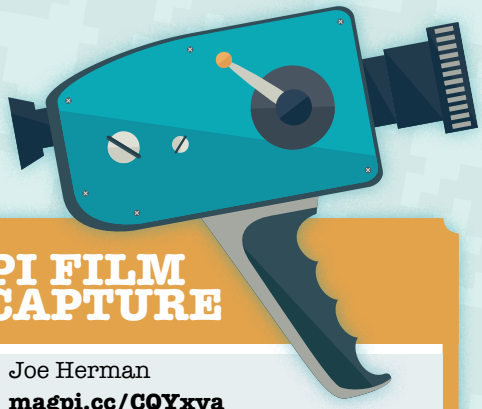
Slide Switches

These are less common, but still found on old audio equipment, especially for volume and balance controls. It's technically possible to wire a slide switch to the Raspberry Pi, but this will often need an interface board and extra code. A simple workaround is to mount two lever microswitches to the back of the slider switch so that when you move it up and down, the original switch clicks the new microswitches at either end of its range, keeping the old-school slider but letting you code and connect with ease.

Upcycled SUPERSTARS

NEED INSPIRATION FOR A PROJECT? NOT QUITE SURE WHAT YOU CAN UPCYCLE? HERE ARE SOME AMAZING BUILDS TO LEARN FROM





PI FILM CAPTURE

- Joe Herman
- **magpi.cc/CQYxya**

This is a very interesting project because it not only uses an ancient reel-to-reel projector with old film, it modifies it for a completely different process than actually projecting film. Instead, it uses the Raspberry Pi and a Pi Camera Module to photograph each frame in a reel of film to convert it into a digital file.

Joe's cousin and uncle uncovered a box of 130 reels recorded by his grandfather. Leo's movies "dated back to 1938," Joe revealed in our issue 56 project showcase. The preservation of these memories was important for Joe's large extended family. But to have them professionally restored would have cost "many thousands of dollars."

The Camera Module is stripped back and placed directly in the lens housing, which removes any interference from outside light. The film is captured one frame at a time, sending images to a client computer for storage and editing. The Raspberry Pi then controls a motor to move to the next frame. It's very smart!

1975 HITACHI PI INFO-TV

- Martin Mander
- **magpi.cc/bdwLNg**

This old portable TV has been transformed into a wall-mounted info screen – tech from 1975 being used in a maker trend from 2018 is about as upcycling as you get!

"It displays useful content in a series of full-screen Chrome tabs," Martin explains on the build post. "Turning the tuning dial switches between the pages, just as you'd originally change TV channels. The volume button controls scrolling, the on-off button refreshes the page, and it has a PIR motion sensor so the screen turns off when you walk away.

"It uses a Pimoroni 8-inch 4:3 screen and a Raspberry Pi 3 to display the content, and some custom-made switches allow all of the original TV controls to be used."

PANASONIC BOOMBOX

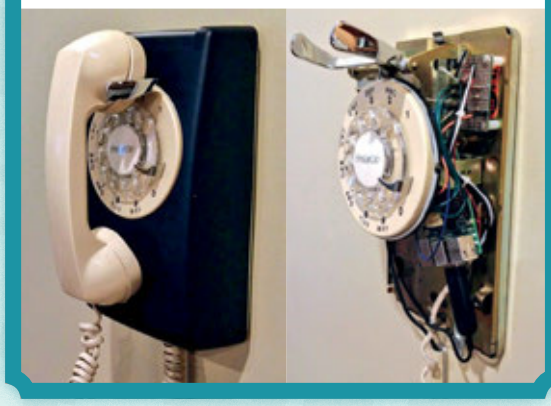
- cheech_sp
- **magpi.cc/wNtLZU**

Rotary phones, CRT monitors, and stereo boomboxes are the favoured pieces of tech used to establish a specific time period. This classic Panasonic boombox has been upgraded with a touchscreen and uses Volumio to stream and play music via a DAC to the original speakers – so it sounds like the old boombox does, but with newer tunes.

RETRO PHONE

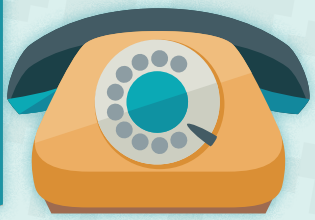
- Arden Albert
- **magpi.cc/uCJKBW**

When the AIY Voice kit came bundled with issue 57, we saw a lot of people use it for cool things. We've previously shown it in Martin Mander's intercom project, but we also like this 1970s (or 1960s?) rotary telephone that has had a Pi and the AIY kit carefully stuffed inside so it works as a personal assistant. All you need to do is dial zero and you can get answers to your queries from the operator (nice Google lady).



CRT Television Warning

Old CRT (cathode ray tube) televisions can carry potentially lethal amounts of electricity for many years. Do not work on a CRT television if you do not have the necessary experience and tools to properly discharge and make safe a CRT. See this excellent Peachpit guide for more information on CRT televisions: **magpi.cc/crt**.



1979 BANG & OLUFSEN RASPBERRY PI INTERNET RADIO

- Martin Mander
- **magpi.cc/QpxzLJ**

"This is a 1979 Bang & Olufsen Beocord 1500 cassette recorder that I've converted into a standalone Raspberry Pi internet radio," wrote Martin. "The analogue VU meters are driven by the Pi via a DAC (digital-to-analogue converter) circuit, with the current time, station, and track displayed on an Adafruit negative RGB display, visible through what was originally the cassette window. It's completely controlled with the original buttons, and the amplification is provided by a reused TV soundbar, which is built into the front of the case."

It sounds like a big project for such an unassuming final product. Unlike some of Martin's other projects, this one has been kept to look more like the original, so you could easily confuse it with the real thing!

1981 PORTABLE VCR RASPBERRY PI MEDIA CENTRE

- Martin Mander
- **magpi.cc/2d3pedC**

We've always loved this more in-depth build that Martin made using an old VCR. The tape ejection system still works, so Martin included it in the build by having the tape inside work as a USB hub that is connected to the Raspberry Pi.

It runs Kodi (well, XBMC on Raspbmc as it was made a few years ago) and uses all the old physical buttons to control the system. It even includes a snazzy paint job and Pi branding.

"It's controlled via a standard media centre remote control (or mobile app)," says Martin, "and does a cracking job of streaming content via WiFi from the BBC iPlayer and YouTube, as well as playing internet radio and files from the local network or USB storage."

VICTORIAN-ERA VANITY DRESSING TABLE

- Andy Wisdom
- **magpi.cc/2sq2CyG**

Probably the oldest thing in this list, we adore the concept of this antique dresser upgraded with a Raspberry Pi. It's all a bit secret agent. The great thing is that it's relatively easy to do the electronics part. Magic mirror software is super easy to set up and install, so the hard work is sourcing and modifying the kind of dresser you want to use.

"Worked on this for about two weeks," Andy wrote about it. "Parts include a Raspberry Pi 3, 32-inch LED flat screen, old furniture, fancy two-way mirror, and some scrap wood for bracing. There's not much to mounting the TV; wife helped a lot here. Due to the age of the furniture (117+ years), we had to brace things up a bit.

"Current modules are a calendar, weather, Nest info, today in history, news/RSS feed, a picture of the moon that represents the current phase or shows the currently playing song on Spotify, and last is a semi-current view of the Earth from the Deep Space Climate Observatory Satellite."

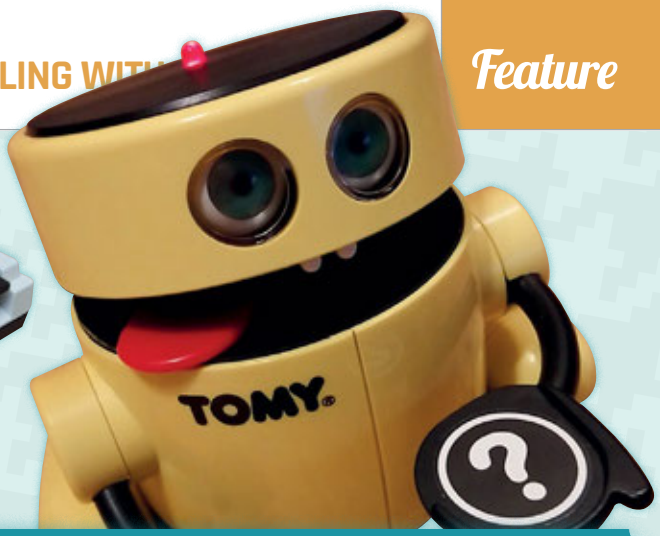
1986 GOOGLE PI INTERCOM

- Martin Mander
- **magpi.cc/2vPQK6E**

This classic intercom is not the first audio assistant project that Martin made – he also modified a toy rabbit and a 1970s telephone with Alexa before the Google AIY Voice kits were released with issue 57 of *The MagPi*.

We especially like the custom finish on the plastic to make it fit in a bit more with modern decor while still having the retro design flair.

"The moment I scooped the Google AIY kit, I knew that one of these old units would be a perfect match for it," Martin wrote. "After all, both were essentially based on a button, microphone, and loudspeaker, just with different technology in between."



TOMY MR MONEY GOOGLE AIY ASSISTANT

- Matt Brailsford
- **magpi.cc/PKHCRv**

Unfortunately, Matt was unable to get the AIY Voice kit when we released it with issue 57 (sorry, Matt!), so he decided to hack his own together… using a Mr Money money-box. As you do. The cute/creepy coin muncher is a retro classic that gives us odd pangs of nostalgia we're not quite able to place, so to see it upcycled in such a unique way is amazing.

Matt used a Pi Zero and a Speaker pHAT to power his project (both small enough to fit in the robot's body), and converted the arm that you'd usually place coins on into a lever/button that activates the assistant.

"Another key function of the original toy is the opening and closing head which I really wanted to have move as it talks," Matt wrote on his blog. "To achieve this I chose to use a micro servo. I figured out a mounting point for the servo in the neck area on the underside of the head. To hold the servo in place, I created a bracket on the laser cutter and fixed it to the head. To make the head actually move, I attached some paper-clip wire from the servo horn through a small hole I made in the upper part of the head. Now when the servo moves, it pushes and pulls the head open and closed."

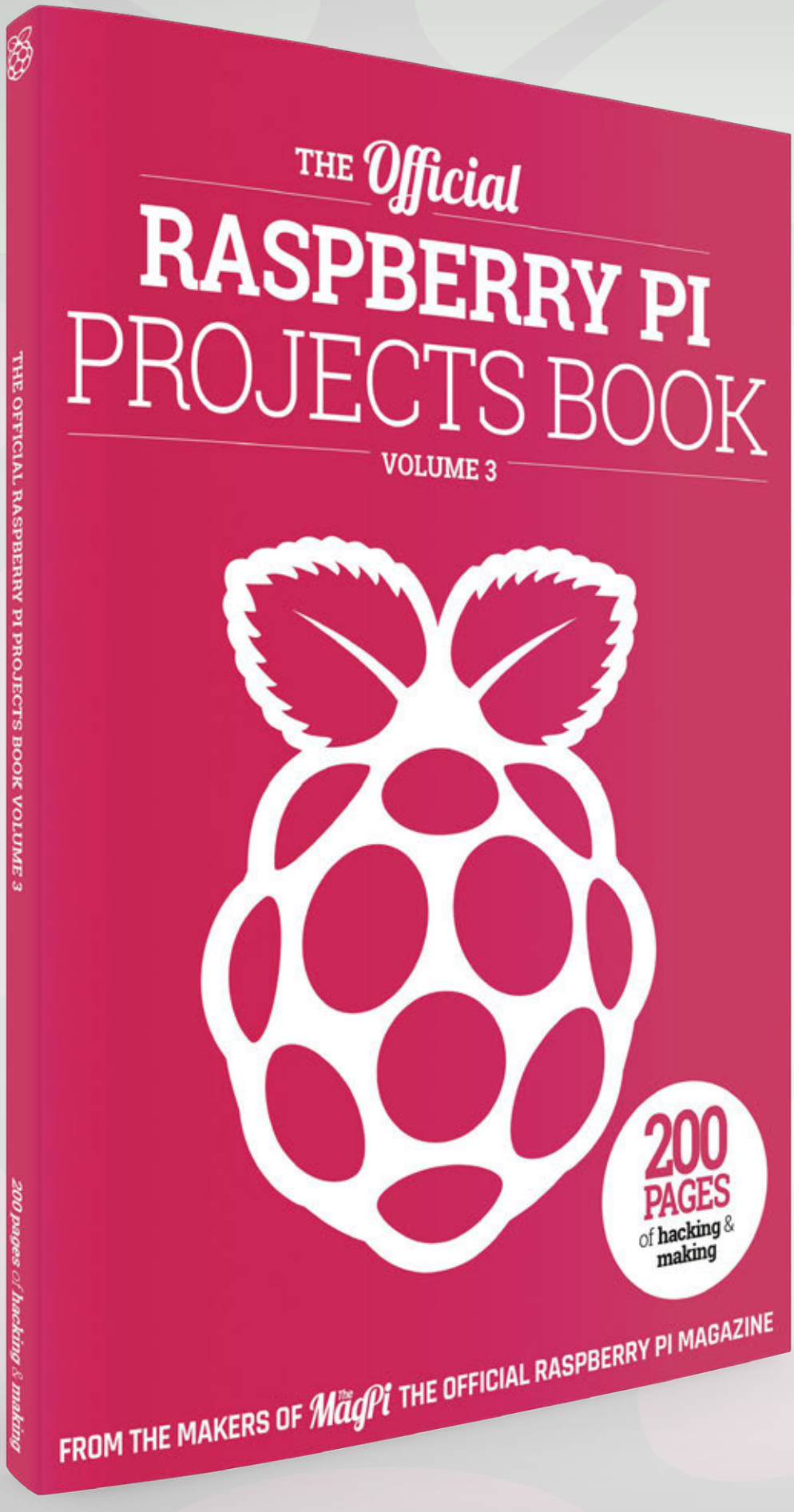
TOMY TURNIN' TURBO DASHBOARD OUTRUN ARCADE

- Matt Brailsford
- **magpi.cc/RgfQql**

Matt has made a name for himself creating incredibly complex and every-bit-as-much cool Raspberry Pi projects, and we had to once again highlight his fantastic toy conversion to play arcade classic Out Run.

You play the game with the built-in steering wheel and gear shifter, and the console lights are used to represent what's happening in the game. It's a frankly amazing project.

"Some key features are an integrated 3.5-inch TFT screen, fully usable steering wheel and gear shifter (dashboard turbo light comes on when in high gear), working ignition key for power, true MPH speed and rev counter displays, and a fuel gauge to represent the stage time remaining," Matt wrote. "The project itself was quite a big one for me, filled with several moments of frustration, from burnt out potentiometers, to soldering LEDs backwards, multiple TFT screen purchases, and more than one change in direction as approaches to problems were found to be inadequate."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Maker Says

"You'll understand more about the weather where you live"

Maker Life

MAKER LIFE WEATHER STATION

Whatever the weather, monitor it in detail with this complete kit's sensors and Raspberry Pi Zero W. **Phil King** has the weather report...

Related

ENVIRO PHAT

This Zero-size board can monitor barometric pressure, temperature, light, and motion. Four analogue inputs enable extra sensors to be connected.

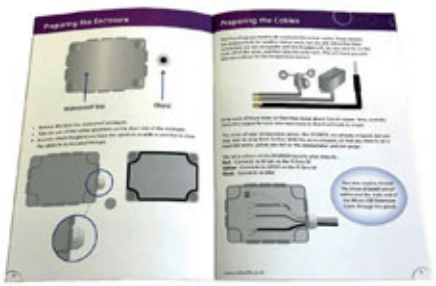
£16 / $18

magpi.cc/suUiJh

Building a weather station is often high on the list of prospective projects for Raspberry Pi users, enabling them to monitor the meteorological conditions where they live in detail. While you could source the components separately, Maker Life offers a convenient alternative with this comprehensive kit.

Inside the impressively large cardboard box you'll find everything you need, including a Raspberry Pi Zero W with pre-soldered GPIO pins, NOOBs microSD card, power supply, and various cables and adapters. Naturally, since you'll be placing the weather station outdoors, there's a waterproof container to house the electronics: a Schneider Electric polypropylene junction box. There's no obvious way of securing the Raspberry Pi inside it, but it seems robust enough and you can use one of its ten cable holes (sealed with rubber grommets) to pass the various wires in.

The kit features three sensors: an anemometer (to measure wind speed), rain gauge, and DS18B20 thermometer. Interestingly, the anemometer and rain gauge are sourced from ailing retailer Maplin;



made of plastic, they're inexpensive options, but do the job well enough. Indeed, the same items were used in the Raspberry Pi Foundation's own weather station kits sent out to schools. A two-part metal-tube mast is also included to mount the anemometer above the ground.

Stripping wires

Unlike some other kits we've seen, there's no add-on board included – instead, all the sensors need to be connected directly to the Raspberry Pi Zero W's pins. In the case of the thermometer, this makes use of the Raspberry Pi's 1-Wire interface on GPIO04, so requires a 4.7kΩ resistor between the data and 3.3V power lines. Before connecting the sensors, you need to chop off their cable ends and strip the individual

magpi.cc/zRQelu

£85 / $115

wires. These are then connected to the Pi Zero's pins via jumper cables and an electrical terminal block – it's a rather fiddly process trying to get the thin wires to hold firm.

The wiring is illustrated in a diagram in the kit's 48-page glossy booklet. Unfortunately, we noticed that this shows the rain gauge's ground wire connected to the wrong pin (GPIO21 instead of GND), so you'll need to watch out for that.

modifications, however, it can be made to write data to a CSV file for later analysis and charting. Of course, there's always the option of sending data to a web-based dashboard if you wanted, although this isn't covered in the booklet.

Step outside

Once all the wiring and coding is complete and tested, you're ready to place the weather station outdoors. The four

> "Inside the impressively large cardboard box you'll find everything you need"

Otherwise, the illustrated booklet explains things fairly well, including the Python example code which you can either type in yourself or download. To help you do so, the kit includes all the cables and adapters required to connect the Pi Zero up to a TV/monitor, and your own mouse and keyboard via a USB hub.

While the example Python code uses threading to gather data from all three sensors simultaneously, it's a fairly basic program that simply prints the current readings to the command line. With a few cables – including a micro USB power extension – pass through a plastic gland screwed to the electronics container; for a more secure seal, it's recommended to wrap the cables in electrical insulating tape.

If you want to communicate with the station remotely via SSH, it will need to be in range of your wireless router. Alternatively, you could simply get it to automatically run a data-logging program from boot. It also needs to be within 4 m of a mains socket, unless you plan to power it from a battery pack (not supplied) or possibly even a solar panel.

Just our luck: we tested the weather station out on a sunny weekend with no rain and very little wind, but it all worked perfectly and seemed to give accurate readings – we cheated by blowing on the anemometer and pouring some water down the rain gauge!

Last word

Compared to the cost of sourcing all the components individually, this kit represents good value for money and a convenient package for creating your own weather station. It could also be easily extended to include extra sensors, such as a wind vane, if needed.

★★★★☆

magpi.cc/kLXibs

£27 / $10

Maker Says

"This Raspberry Pi 3 case is the best solution to help build your own video game console

Collector Craft

SUPER TINYTENDO CASE

Rob Zwetsloot discovers that this SNES case is no ordinary retro throwback

In issue 68 we reviewed the Kintaro NES case – a simple concept that's been done by many folk with access to a 3D printer, although it had the neat little gimmick of a flip-up cart-slot that gave you access to the USB ports on the Raspberry Pi.

On the outside, the Super Tinytendo looks pretty basic in comparison – especially at the price tag of £27. However, it hides a big surprise: a fully functional case fan. This may not sound like much, and it probably won't help you in your quest to create the perfect tiny retro console, but it's a rare thing for a Pi case to include one. It connects very simply with a little plug over a couple of GPIO pins, with vents along the bottom to allow air flow.

Easy fitting

Otherwise, fitting the Raspberry Pi inside the case is very straightforward. Four sturdy screws keep both parts of the case together, and removing them reveals an obvious recess for the Pi to sit in. It can be then screwed down to the bottom of the case, although you will need to provide the screws for this yourself. It will stay in place without these screws, but it's not particularly sturdy.

Access to power and AV ends up at the rear of the case, as on a classic SNES, with the USB ports exposed on the side of the case for controllers.

The original American version comes with a power LED that's missing from the UK version, although it does make it easier to set up because of this.

The case itself is created from injection moulding and is pretty sturdy because of it. The Power and Reset buttons from the original SNES are lovingly recreated, although they're unusable and serve as a reminder that this is the ugly, purple-and-grey American SNES body and not the classic, sleek European one.

Still, transatlantic aesthetics aside, it is a pretty nice case, although one that might actually end up being more useful for people that regularly push the Pi to the limit and need some extra ventilation options.

Related

KINTARO NES CASE

A cheaper and slightly different retro gaming case that may suit your needs better.

£15 / $20

magpi.cc/PDIDML

Last word

A great, sturdy case with surprisingly good ventilation options that make it useful beyond its intended retro gaming applications.

★★★★☆

CoderDojo

Can I start a CoderDojo club in my local area?

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- Maroes, CoderDojo NL

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Part of Raspberry Pi

Maker Says

"Our most popular Raspberry Pi robot kit is back with faster motors and a newly designed chassis!"

PiBorg

DIDDYBORG V2

Rob Zwetsloot takes PiBorg's current flagship hobby robot for a spin

Related

CAMJAM EDUKIT #3

A kit for robo-beginners, the CamJam EduKit also comes with some neat sensors you could then use when you upgrade to the DiddyBorg.

£18 / $24

magpi.cc/RhojZh

We're always excited when a new PiBorg product crosses our desk. The team have a history of the making top-quality Pi robot kits, and the new DiddyBorg looked to be no exception.

This DiddyBorg is a six-wheel powerhouse built on a sturdy acrylic and metal chassis. It's controlled by a Raspberry Pi (that you supply yourself) and the ThunderBorg – the dedicated robot controller that controls several motors and has I²C pins for adding sensors etc. These boards are stackable so that you can add more motors and such, and they handle the current from robot-appropriate batteries to power both the motors and the Pi itself. It's a nifty piece of kit on its own, and the DiddyBorg does a great job of giving you a glimpse at its power.

We can rebuild it

Very handy build instructions, complete with relevant photos, are included online for the DiddyBorg (**magpi.cc/iHUOpv**). Construction is fairly easy: just put in a few screws in the right place, solder on a few wires, connect it all up to the ThunderBorg and Raspberry Pi, and you're done.

For the odd bit that is fiddly, there are plenty of pictures to make sure you're doing it the right way, such as plugging wires into screw terminals or perfectly aligning the hubs on the motors for the wheels.

We received our robot pre-constructed, but we'd estimate it'll take a couple of hours maximum to build the kit and set up the basic software on your Raspberry Pi, depending on your expertise. PiBorg recommends using a full-size Pi model rather than a Zero or A+. It would technically work with either of those but it doesn't have the mounting points on the chassis, so you'd have to do some customisation if you insisted on using them.

Customising your bot

Although there are no immediate mounting points for, say, a Pi

magpi.cc/eUEseN

£210 / $285

Zero, there are plenty of extra mounting points along the chassis for sensors and such which can be connected to the Pi directly or via the ThunderBorg where appropriate. Out of the box, it works well as a remote-control robot but with these extra sensors and a Pi Camera Module, you can turn it into a true automaton.

All the code is done in Python and allows for a lot of control over how the DiddyBorg functions. Some of the code examples might seem intimidating to first-time robot builders, but they are explained pretty well so with a bit of trial-and-error even Python beginners should be able to cobble together code to make the robot do what they want.

It does mean though that advanced robot hobbyists have a greater level of control over the DiddyBorg than they might do with other robot kits. And due to the quality of the DiddyBorg, it would serve well as a base for a bigger robot project or even just a test bed for other builds.

High performance

With six powerful motors and a sturdy base, the DiddyBorg is a very stable and powerful bit of kit. It won't zip off at the mere touch of a controller, and this means it also has a fair bit of torque behind the wheels. The motors can be finely controlled with differing power requirements, so its speed can vary depending on how you need to use it, which is very nice.

> "The motors can be finely controlled with differing power requirements"

While we miss the full-metallic builds of older PiBorg kits, the acrylic chassis is a bit easier to work with and still extremely strong. It can take a small hit or a tumble and still work just fine, making it perfect for testing, while still being excellent as your actual main robot.

It's not something we'd recommend for beginners, though – PiBorg has other, simpler kits anyway which may be better suited to that. However, as a lot of Raspberry Pi robot kits skew towards being beginner-friendly, it's nice to see something aimed at a more veteran audience who would appreciate it at the (relatively) low price.

Last word

A big kit for big people, this powerful robot kit can be used in almost for any Raspberry Pi hobby robot solutions, although we'd say it's not really for beginners.

★★★★★

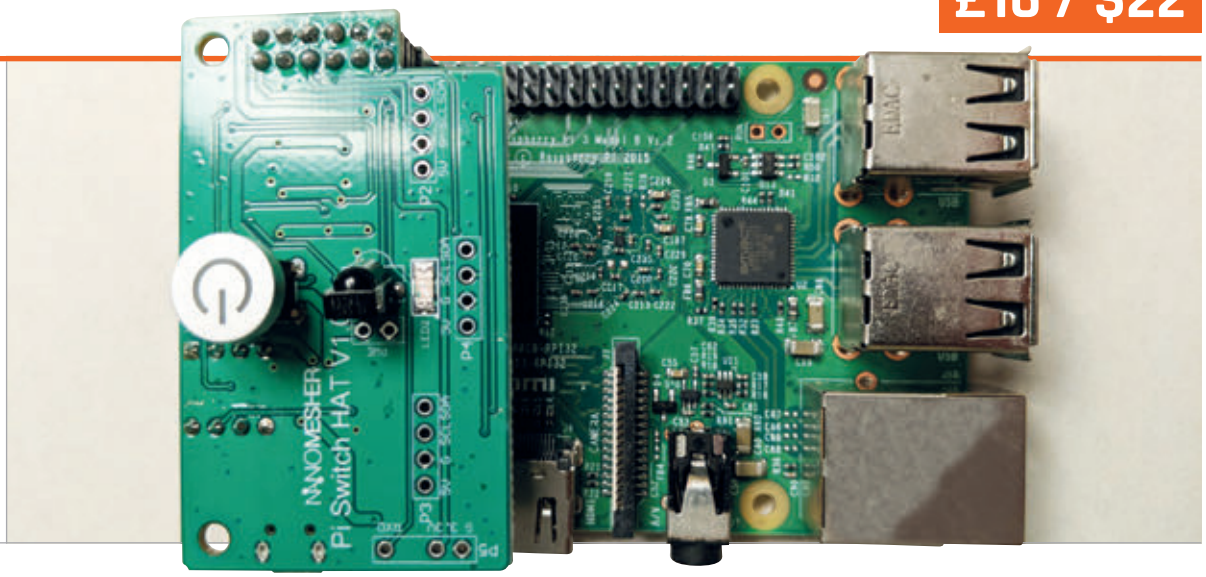
magpi.cc/cwNDmz

£16 / $22

Maker Says

"Huge improvements over our Hackable Pi Switch with Kodi support"

Nanomesher



HACKABLE PI SWITCH CAP

This updated Pi Switch features fewer wires and an expanded remote control. **Rob Zwetsloot** gives it a test run

The Raspberry Pi has been out for six years and three months and we can finally say that the perfect on/off switch add-on for it has now been created. This upgraded version of the previous (and also excellent) Hackable Pi Switch has ditched the cable-filled setup for a much more streamlined version that also offers some truly special extras with the addition of media remote control support.

The Cap part of the name signifies that it connects via the GPIO pins, sitting on top of the Raspberry Pi much like a HAT. It only uses the first twelve GPIO pins, though, leaving 28 spare on (most) Raspberry Pi models so that you can attach more bits, which is nice. These twelve pins provide power to the Raspberry Pi, as well as allowing for an interface for the remote controls which you can get with it.

It looks like a much neater fit when it's installed on a Raspberry Pi as well, and uses the same 5 V micro USB input port as the Pi itself so you don't need to use a different power supply with it. The Cap will wait for you to press the nice power button on the board or press the power button on the remote and start providing power to the Raspberry Pi. It will then turn the Pi off with a software shutdown, but it also supports a hard power-off – and it's still hackable, just like the original Pi Switch.

Extra features

The remote support is a great addition, with some default Kodi support as part of it. It's LIRC compatible as well, so you should be able to adapt universal remotes to work with it. This makes it perfect for media centres.

All of this would be enough, but the Cap also includes optional temperature/humidity and pressure sensors, as well as a tiny OLED screen, allowing it to be used in more traditional utility projects. Even so, we're still going to use our first one with our Kodi Pi sitting below our TV, naturally.

Related

ONOFF SHIM

A much simpler and cheaper concept, this SHIM includes a switch you can use to turn the power on and off, and that's it.

£6 / $7

magpi.cc/itJzUx

Last word

Everything you'd want from a custom power-switch for the Raspberry Pi, and more. The Switch Cap perfects any media centre, but can also work in specific Pi programming projects.

★★★★★

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Maker Says

"With an AstroBox, your printer can finally communicate with mobile apps, desktop software, web portals, and more

Astroprint

ASTROBOX TOUCH

Monitor and control your 3D printer from anywhere with this simple Raspberry Pi-powered plug-and-play device. **PJ Evans** tries it out

Many popular 3D printers come with very basic controls, so preparing a model for printing can be a technical trial. The AstroBox Touch transforms your 3D printer in an internet-connected one-stop shop by linking the printer to the AstroBox cloud web application. It also features a touchscreen interface, allowing for basic printer control that is light years easier than a standard firmware interface.

Setting up

The device itself is a Raspberry Pi with a touchscreen HAT in an injection-moulded case with exposed USB ports, enabling easy connection of your printer and webcam. Setup could be better, as the 'quick start' video really didn't explain anything. Fortunately, we found the user interface very intuitive and it wasn't long before everything was connected. (A Pi Camera Module cannot be used, as there is no access to the camera connector.)

On both the AstroBox site and the touchscreen, you have access to a range of 'apps'. You can download files directly from Thingiverse or MyMiniFactory, slice and start prints, then monitor your work with video streaming and time-lapse recording. Additionally, you can create new objects with some design tools – including 3DSlash, which is a fun way of designing that will appeal to Minecraft fans in particular.

Painless printing

Compared to other cloud solutions, this is a very refined product. We were pleased by the ease of setup, and anything that produces a good print first time gets our vote. Integration with the website worked flawlessly both on desktop and phone. The default settings chosen for our printer were not perfect, but you can adjust them to your heart's content on the website.

The AstroBox Touch is an ideal product if you're looking to make your 3D printing experience less painful. Its plug-and-play nature is worlds apart from other solutions, although you do sacrifice some of the fine-tuning available in slicers like Cura. If you're just interested in easy printing, this may be the device for you.

The AstroBox Touch is not cheap: £175 is a lot compared with the alternatives. What you're buying is an easy, painless experience – and to some people who don't have the time or interest in a more involved technical setup, that may be money well spent.

Last word

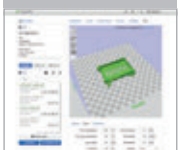
The AstroBox Touch's mission is to transform the frustrating process of 3D printing into a pleasurable and intuitive experience. If the price is right for you, it's an easy win.

★★★★☆

Related

OCTOPRINT

Web-based control of your 3D printer including object slicing and Pi Camera Module support. A more technical setup than AstroBox, but also more flexible and extendable.



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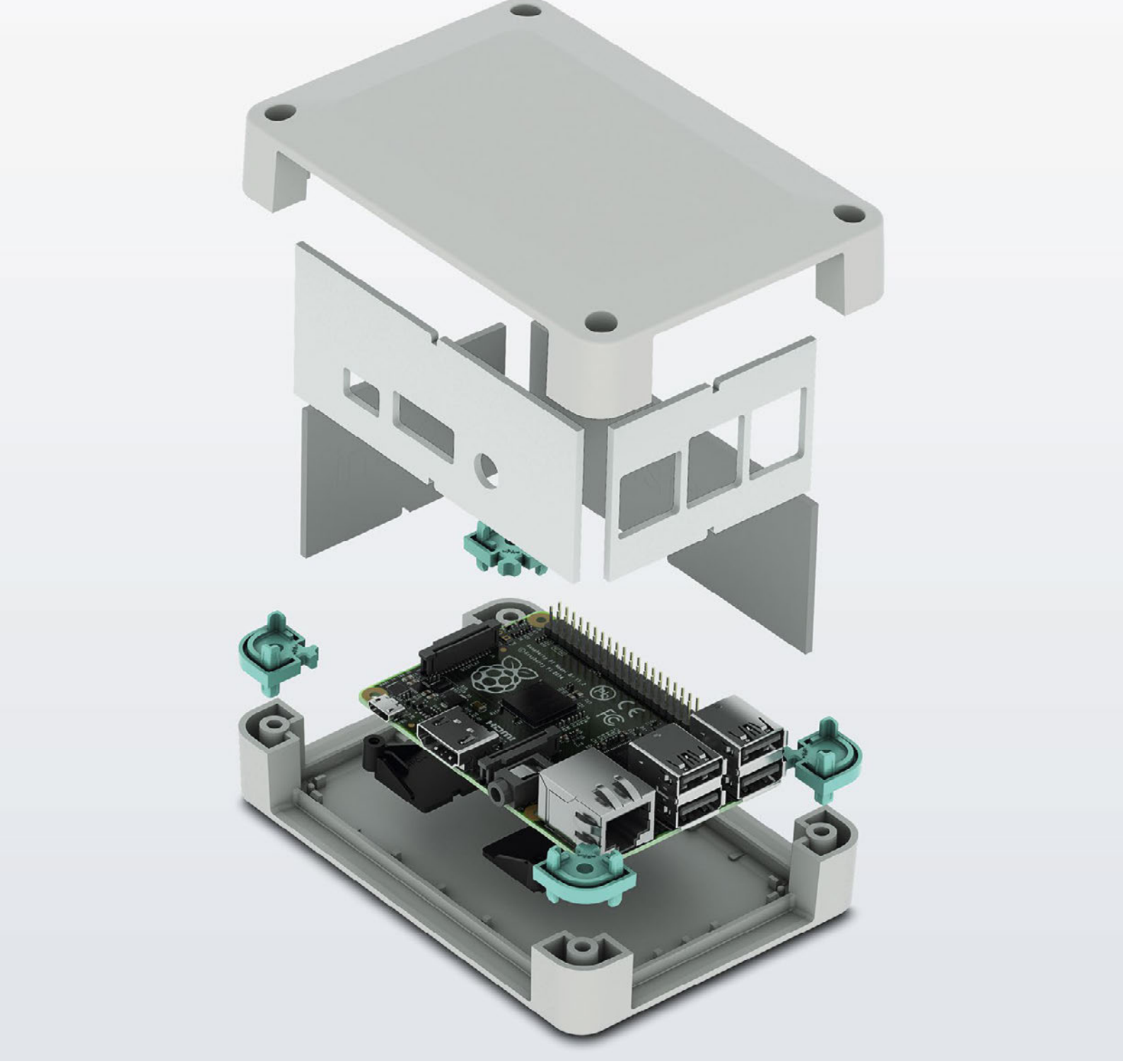
octoprint.org



Raspberry Pi 3 B+ finds a new home

Versatile enclosure for Raspberry Pi 3 B+

The new UCS-RPI Universal Case System is compatible with the recently launched Raspberry Pi model 3 B+. It has pre-milled side walls for easy access to the I/O and power inputs and is available in black or grey and two sizes. Complete with glue dot location posts to secure the single board computer to the case.

For additional information call 0845 881 2222 or visit

phoenixcontact.co.uk/UCS-RPI

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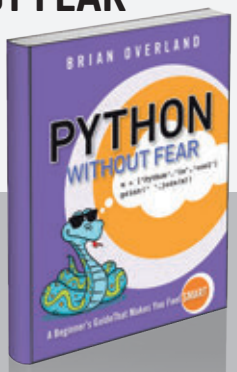
INSPIRING INNOVATIONS

RASPBERRY PI BESTSELLERS ADDISON-WESLEY

Although best known for its Comp-Sci classics on C++ & Java, this publisher can also guide you on your Python journey.

PYTHON WITHOUT FEAR

Author: Brian Overland
Publisher: Addison-Wesley
Price: £29.99
ISBN: 978-0134687476
magpi.cc/FyNyPg



An old-school intro that gets it right, thanks to clarity, good pacing, and a well-judged balance between showing, and then pushing the reader to try; with well-chosen examples, and enough background 'why'.

LEARN MORE PYTHON 3 THE HARD WAY

Author: Zed A Shaw
Publisher: Addison-Wesley
Price: £32.99
ISBN: 978-0134123486
magpi.cc/LpFjqH

Zed Shaw demands hard work from his pupils, but in return promises to improve your code skills, with emphasis on process, creativity, and quality. Recommended for junior programmers with aspirations.

EFFECTIVE PYTHON: 59 SPECIFIC WAYS TO WRITE BETTER PYTHON

Author: Brett Slatkin
Publisher: Addison-Wesley
Price: £29.99
ISBN: 978-0134034287
magpi.cc/EtpiHy

Python is easy to pick up if you can already program in another language, but you'll miss out on a lot of the tricks, to say nothing of true pythonic style, without a native guide – and this is the best.

PROGRESSIVE WEB APPS

Author: Dean Alan Hume
Publisher: Manning
Price: £29.99
ISBN: 978-1617294587
magpi.cc/hAbSLt

Readers may be familiar with responsive web design, where content is available on all devices. However, unobtrusive JavaScript and progressive enhancement makes for a more compelling experience on devices that support all of the bells and whistles, without shutting off users of older devices, or with limited connectivity, from accessing your content. *Progressive Web Apps* (PWA) shows how to go beyond this with sites that give an app-like experience, and can even work offline, yet work with all browsers and devices.

The main ingredient is Service Workers, which intercept and route HTTP requests, loading the page from the web or the cache. Not only can this make sites work offline, but it dramatically speeds up page load times, as well as (perhaps most important) perceived load times.

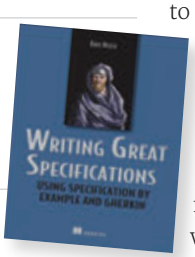
This slim but practical work explains the key concepts, shows you the code, then walks you through building your first PWA. This itself is progressively enhanced, to make it more engaging. Look and feel are addressed, then 'engaging users with push notifications'.

'Offline experience' and 'keeping your data synchronised' take the reader through to the final section, 'looking forward to new and upcoming libraries', enabling features like streaming, Bluetooth connection, payments, hardware access, and even shape detection.

Score ★★★★☆

WRITING GREAT SPECIFICATIONS

Author: Kamil Nicieja
Publisher: Manning
Price: £24.99
ISBN: 978-1617294105
magpi.cc/kTeAuz



Specification by example (SBE) takes story-based descriptions of how software should work – which involves the whole team, not just technical staff, collaborating on analysing the use-case scenarios. It makes these concrete by capturing requirements and producing automated functional tests that are also the basis for documentation. An advantage of these concrete requirements is that most people find it easier to understand such examples than an abstract spec, and teams are quicker to reach an understanding of the business problem being addressed.

Nicieja does a first-class job of going from the abstract to the concrete himself, going from the 'why' of specifications to the 'how', with Gherkin – a "business-readable, domain-specific language [providing] a framework for business analysis and acceptance testing," which helps you to look at requirements from the perspective of a user's workflow. How to write scenario outlines gets excellent coverage, with time spent on anti-patterns, and the results of getting it wrong, as well as best practice.

Practical problems of managing the Gherkin documentation are covered, along with using the Cucumber testing tool, addressing issues like documenting non-functional requirements ('quality'), and scaling up to very large projects. If your experience with specifications has been negative, time to try SBE.

Score ★★★★☆

ADVANCED GAME DESIGN: A SYSTEMS APPROACH

Author: Michael Sellers
Publisher: Addison-Wesley
Price: £43.99
ISBN: 978-0134667607
magpi.cc/XWlTeR

While there's no question that serious games developers will benefit from this book, what makes it more interesting to curious and engaged readers of all sorts (we're talking about *The MagPi* readers here, clearly), is that any coder – and even non-coder – can benefit from Sellers's extraordinarily clear introduction to Systems Thinking, which makes up the first of Advanced Game Design's three sections.

In today's complex and changing world, only a view that can traverse levels of organisation – from quarks to constellations – and see 'things' as more than the sum of their parts, can avoid simple-but-wrong solutions to the problems we face. Apply that same thinking to the complex world of immersive games and you can keep players deeply engaged.

The remaining sections on game design in principle and practice cover several levels and integrate the approach of different sorts of game designer (storyteller, inventor, toymaker) into designing systemic games. Loops appear often here, and in the practical sections – which take the games designer all the way through to pitching and playtesting. The game's model loop and various gameplay loops will get you rethinking how you model even fairly simple games. A useful and interesting read.

Score ★★★★☆

EFFECTIVE JAVA: THIRD EDITION

Author: Joshua Bloch
Publisher: Addison-Wesley
Price: £40.99
ISBN: 978-0134685991
magpi.cc/EgSsPP

Although setting the standard for showing the 'correct' way in Java, the second edition covered Java 6, and although many developers are still stuck maintaining code on that (or even earlier) platform, Java 7, 8, and 9 have brought many new language and library features, including lambdas and streams. An update to Bloch to cover these changes has been eagerly anticipated.

When it comes to new library features like the Optional<T> interface, Bloch doesn't just emphasise best practice (appealing to when you know it's wrong by a bad 'code smell'), but also shows the times when it's best to actually break the rules. Not all updated features are wholeheartedly welcomed by the author, but the case for why the programmer should do something is always convincingly argued!

If you've not got the previous edition, this is a must buy for any serious Java coder. Each chapter is divided into short 'Items', and every one of the 90 of them contains wisdom that will lift your Java skills to the next level and beyond, making your code more efficient, and saving you many hours in the future on maintaining your code, so it attains better structure while you attain deeper understanding.

Score ★★★★★

ESSENTIAL READING: YOUNG LANGUAGES

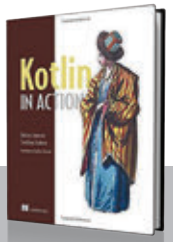
New languages give a chance to learn from mistakes of the past and implement new paradigms.

Programming Rust

Author: Jim Blandy
Publisher: O'Reilly
Price: £47.99
ISBN: 978-1491927281
magpi.cc/uVKhzz

Excellent in-depth guide to the Mozilla-sponsored, "safe, concurrent, practical language" bringing Haskell-inspired type classes to a C++ replacement.

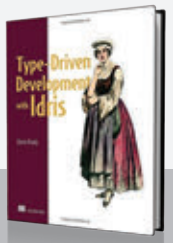
Kotlin in Action



Authors: Dmitry Jemerov
Svetlana Isakova
Publisher: Manning
Price: £24.32
ISBN: 978-1617293290
magpi.cc/tSxPTq

Interfaces, improved function calls, lambdas, higher-order functions, an extensive type system, and a first-class citizen on Android.

Type-Driven Development with Idris



Author: Edwin Brady
Publisher: Manning
Price: £35.99
ISBN: 978-161729023
magpi.cc/ClCRPz

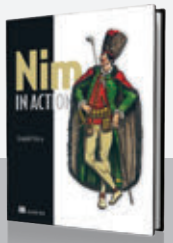
Intrigued by using types to ensure that if the software compiles, most errors have been eliminated? Try Idris and you'll never want to go back.

Think Perl 6

Authors: Allen Downey, Laurent Rosenfeld
Publisher: O'Reilly
Price: £47.99
ISBN: 978-1491980552
magpi.cc/KrxIYf

Perl 6 arrived with little fanfare, and many coders are missing out on a language that improves in almost every way upon its predecessor.

Nim in Action



Author: Dominik Picheta
Publisher: Manning
Price: £30.99
ISBN: 978-1617293436
magpi.cc/jeSuzr

A Python-like syntax, multi-paradigm without putting OOP first, and compiling to C (or JavaScript); Nim is efficient and expressive.

BUILD A COMPUTER

FOLLOW MISSIONS

LEARN PROGRAMMING

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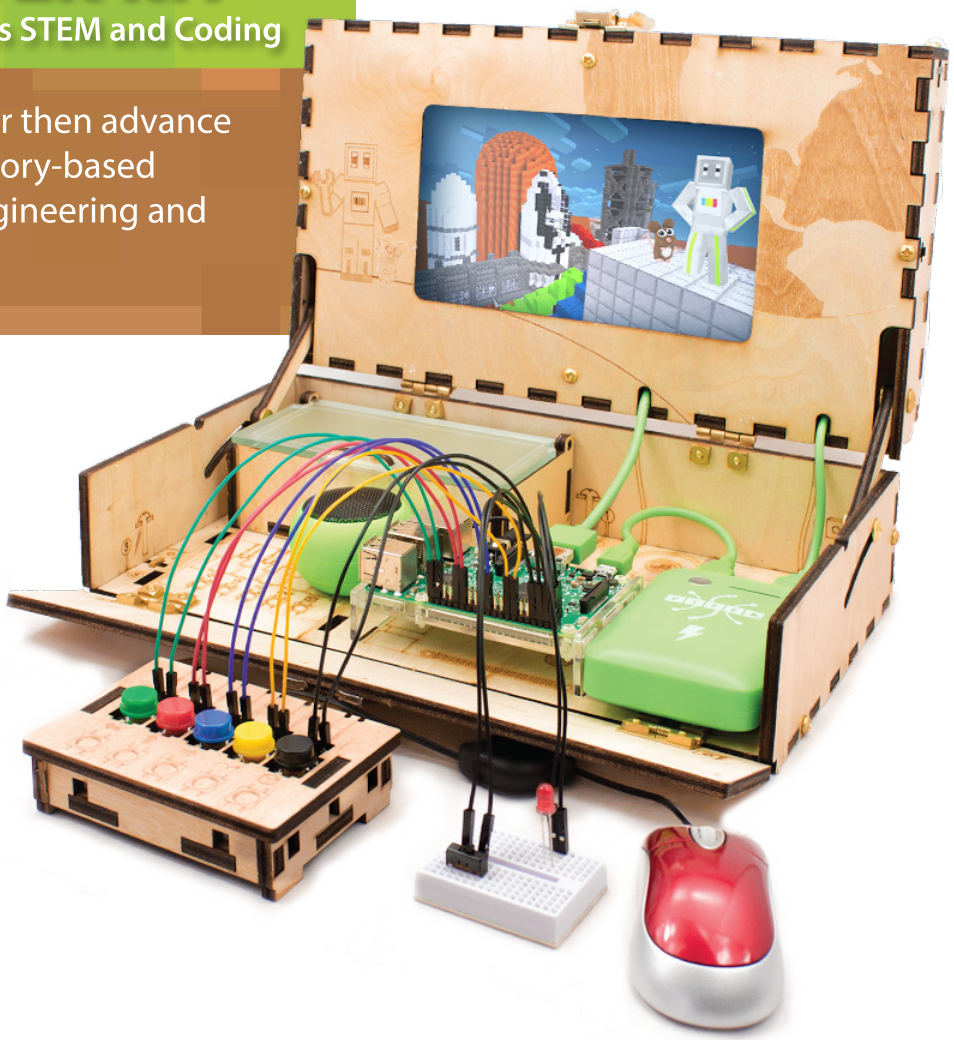

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BRAZILIAN ART MADE WITH RASPBERRY PI

An architect is helping to bring technology to art installations using the Raspberry Pi

Felipe Gomes

Occupation: Architect

Felipe's installations have always attracted plenty of admiring punters

We're great supporters of STEAM here at *The MagPi*. Art is as important as the rest of the technical aspects of computing, so we're always excited to see great art projects that incorporate the Raspberry Pi and the rest of the STEAM spectrum. Felipe has been doing some amazing work incorporating technology into art, so we jumped at the chance to have a chat with him about it.

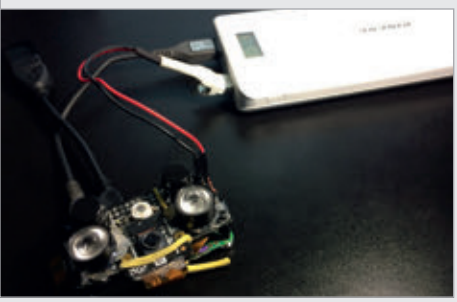
What is it you do with the Raspberry Pi?

I have used the Raspberry Pi models for various purposes, from personal projects for fun to audiovisual and artistic installations. As personal projects and proofs of concept, I have used the Raspberry Pi for light painting, DMX scenographic light control, and as an instant IR camera. As artwork, I did some projection-mapping installations using the ofxPiMapper in Raspberry Pi 3 and some other installations with a thermal printer and the Raspberry Pi Zero W.

Can you tell us about some of your art projects?

The first project I did with Raspberry Pi was at a party where we were invited to do an installation. After setting up an almost invisible projection screen in front of the DJ, I used two Raspberry Pi 3s and two projectors with ofxPiMapper: one projector showing patterns randomly generated and the other showing the DJ through an infrared camera, mixing the signals on the screen itself.

Felipe uses the Raspberry Pi for more than just art projects



Above The infrared sensor used by the DJ to maniupulate projection patterns

Soon after, I built a totem that printed the results of an architectural photography workshop on thermal paper through a Raspberry Pi Zero W, where the participants sent their photos to the printer after the post-production.

Another technical production project I did was with the artist Fabiana Caldart, where she needed a constant fire in the middle of an exhibition. We used the same almost invisible screen and the Raspberry Pi to simulate the fire burning in the centre of the room.

Most of the projects I worked on had the concept developed within the architecture and experimentation office I had with some friends in the last couple of years, the Estudiograma. Even developing the concepts together, the technical production was all done by me.

Why the Raspberry Pi?
It's affordable and easy to use. Besides, the online community is large (and still growing!) so I have good resources to learn and information to make my projects. When using it on art installations, it replaces expensive computers which could break or be stolen, a major problem in Brazilian alternative and independent art spaces. The small size is also handy.

What have people's reactions been to some of the projects?
People are often curious about the intersection of art and technology because they don't know how easy it is to program a pocket computer for a specific task. When I show that everything is being done by a Raspberry Pi, the astonishment is bigger because it's not so popular in art projects in Brazil. One of the installations of the artist Fabiana Caldart, in which I did the technical part, had a great repercussion, as we saw by the amount of photos found in the Instagram streams of visitors to the exhibition.

The study group is one of the few Pi gatherings in the country

JOIN IN WITH BRAZILIAN MAKERS

Interested in collaborating or chatting with other makers and live near Curitiba in Brazil? Felipe has started what he calls a 'study group' which has artists, designers, programmers, architects, and other folk turn up to talk about making once a week.

You can find out more information, along with other examples of Felipe's work, at the following websites:

felipesg.cargocollective.com
estudiograma.com
magpi.cc/apiYyF

Did you use it for anything before the art projects?
I started using Raspberry Pi to set up an arcade. After this, I set up the server of the architecture office where I used to work; it not only managed the files but also showed the emails, the financial control, and a calendar with all the office tasks in a display. While in college, I used a Raspberry Pi 3 with a touch display as a Google Forms portable poll device for some urban-related researches.

What future plans do you have?
At the moment, I am in the middle of two installations – projects of my own. One of them, which is already more developed, features a Raspberry Pi Zero W with the infrared camera to take pictures in the dark and send them over WiFi to a second Raspberry that will [print] these photos in real-time, like an instant camera but with the printer in a fixed place.

My intention now is to focus on this intersection between art, technology, and built space.

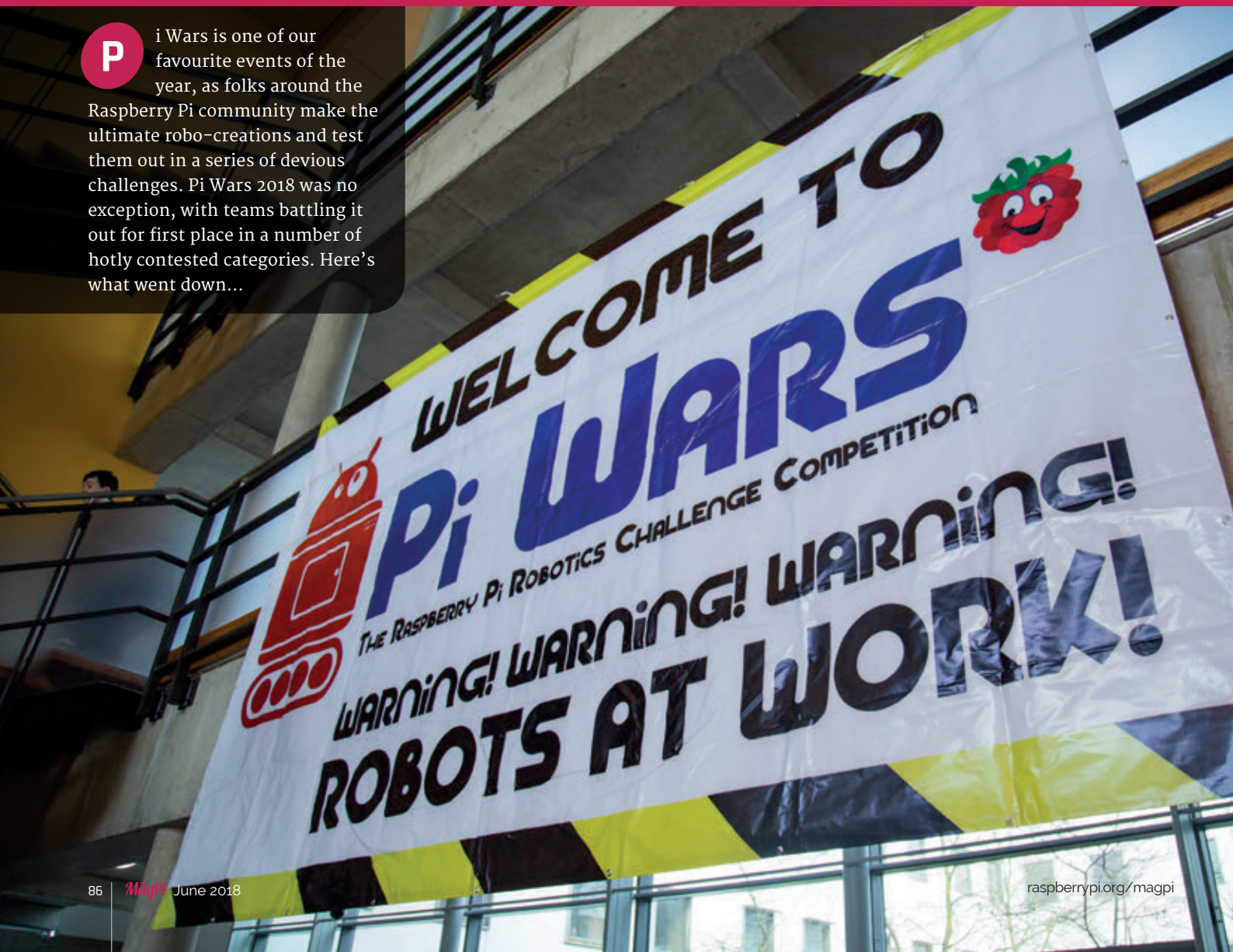
THE MONTH IN RASPBERRY PI

Everything else that happened this month in the world of Raspberry Pi

PI WARS 2018

THE AUTOMATONS BRAVELY FOUGHT FOR DOMINANCE AT THE PREMIER PI ROBOT CHALLENGE

Pi Wars is one of our favourite events of the year, as folks around the Raspberry Pi community make the ultimate robo-creations and test them out in a series of devious challenges. Pi Wars 2018 was no exception, with teams battling it out for first place in a number of hotly contested categories. Here's what went down...

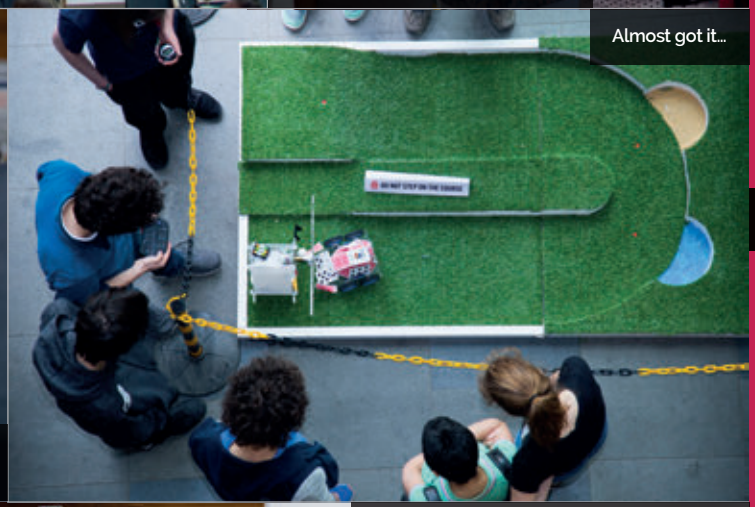


The event was a bustling festival of hobbyist robotics

The robot golf challenge is trickier than it looks

Competitors of all ages attended the weekend-long event

Robot Wars judge Dr Lucy Rogers was on hand to judge the Pi-bots



Almost got it...

Tensions ran high in the new Pi Noon arena

WINNERS!

After the end of a gruelling weekend, only a few robots can roll home winners. Here's the overall winners in each class – head to **magpi.cc/uAHsqE** for a full breakdown of the individual events!

SCHOOL TEAM RESULTS

1st **DCGS**
Lydia Timpson

2nd **Robot Apocalypse Committee**
Melissa Bustamante - Team 1

3rd **Autonomouse**
David Clark

BEGINNER TEAM RESULTS

1st **Medway Makers - M.E.R.P.**
Mike McRoberts

2nd **Paranoid Android**
Paul Hodgskin

3rd **Radioactive Funky Chickens**
Robert Westwick

INTERMEDIATE TEAM RESULTS

1st **X-Bot**
David Pride

2nd **Robo-Top**
Cat Lamin

3rd **Eternal Jamnation**
Claire Gurman

ADVANCED/PRO TEAM RESULTS

1st **Tractor Bot**
Phil Willis

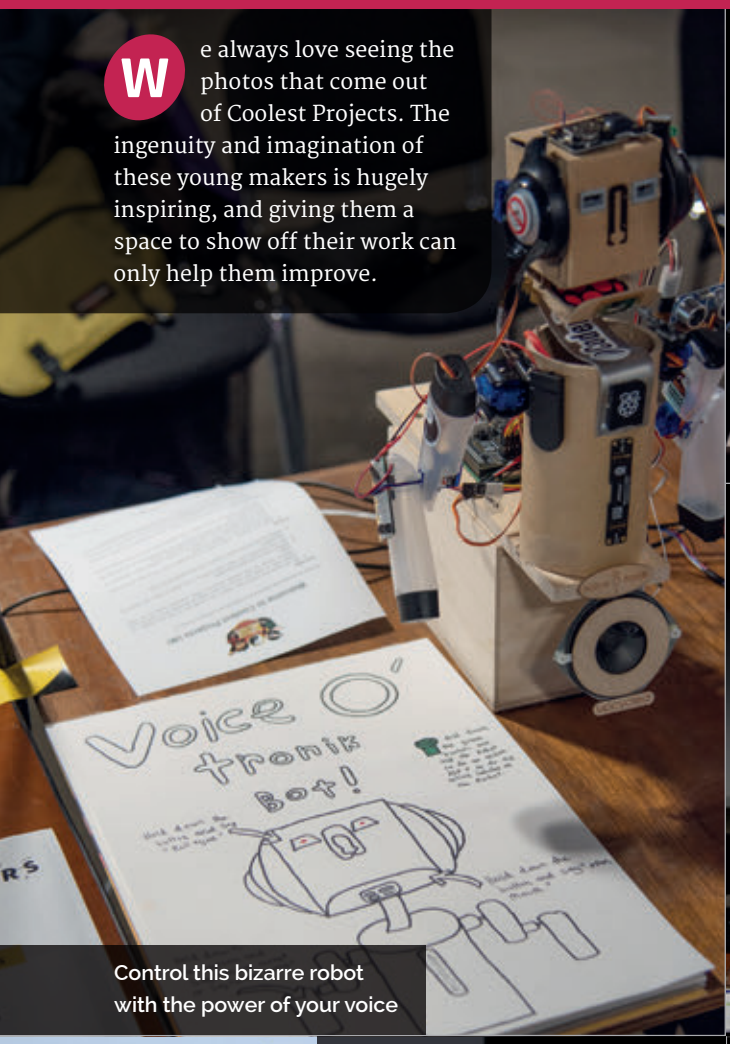
2nd **Coretec Robotics**
Brian Corteil

3rd **Tigerbot**
Lancelot 'Lance' Robson

COOLEST PROJECTS UK

CoderDojo bought the amazing Coolest Projects event to London

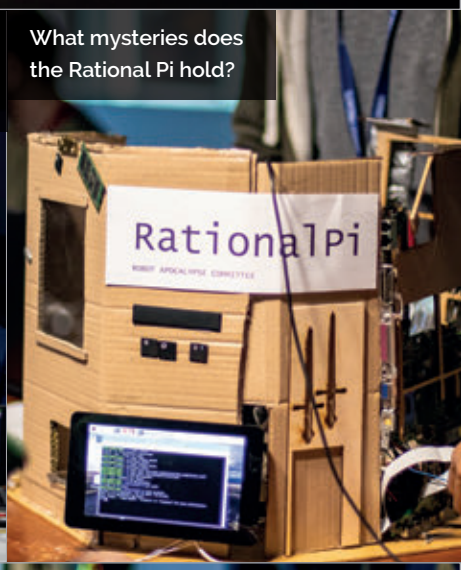
We always love seeing the photos that come out of Coolest Projects. The ingenuity and imagination of these young makers is hugely inspiring, and giving them a space to show off their work can only help them improve.



Control this bizarre robot with the power of your voice

Fun talks to inspire the Ninjas were held throughout the event

The sky isn't even the limit for CoderDojo Ninjas – they can go straight into space



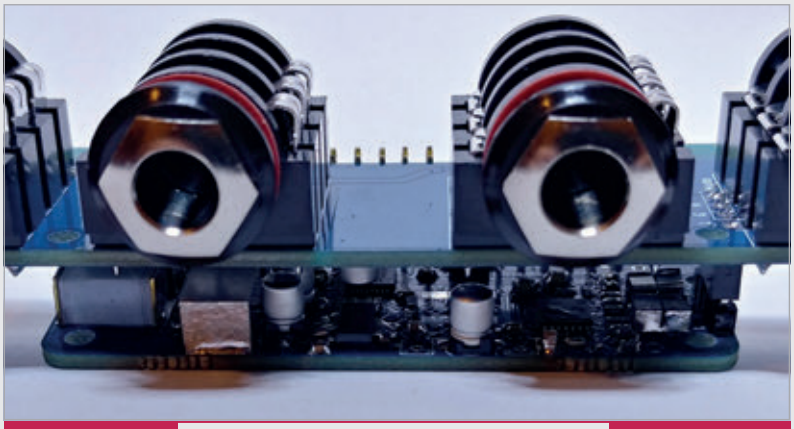
What mysteries does the Rational Pi hold?

Raspberry Pi Foundation CEO Philip Colligan was on hand for expert tips

Get dancing with Dance Magic!

CROWDFUND THIS!

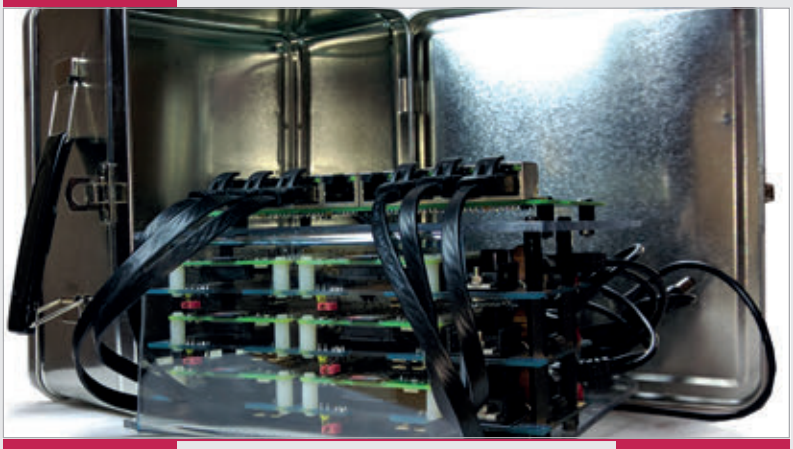
The best crowdfunding hits this month for you to check out...



kck.st/2H5vnDM

AUDIO INJECTOR ULTRA SOUND CARD

Another chance to help back a high-quality sound card for the Raspberry Pi! This one supports high-fidelity input and output of 192 kHz, and supports digital optical (S/PDIF) sound. It even has dual microphones on the board. Apparently, the 'ultra' in the title refers to its premium components. Give it a look!



kck.st/2rGn8ID

PORTABLE CLOUD

Is there really such thing as a portable cloud? Or are portable clouds just wireless network-attached storage? Bottledwind thinks they can be a reality, and has created this lunchbox-sized Pi cluster that it claims acts as a development cloud environment. It looks pretty cool, to be fair.

BEST OF THE REST

Here are some other great things we saw this month

TRADING CARD SCANNER/ORGANIZER

While this is the kind of Raspberry Pi project that would have Homer Simpson yelling "Nerd!" out of his car window, we do appreciate the complexity of a system that scans and logs individual trading cards and even allows you to keep track of the value of your collection. We wonder how it works with shinies?

magpi.cc/YyscOC

PI ZERO ALL-IN-ONE POWER PLUG

magpi.cc/EsAkCR

While not a wholly new idea (we've been doing this since before the Pi Zero was announced!), this is one of the few versions of the Pi Zero plug we've seen with a pretty nice case that's completely enclosed. Perfect for portable Pi projects, and even as a portable NAS device.

MOTION-DETECTING BIRD CAMERA

Reddit user bigluzer has posted a load of really cool pictures of birds that have been snapped by their latest project. We like that it also highlights how it's detecting that a bird is in view. Plus we also like seeing pictures of birds. Who doesn't?

magpi.cc/zNqgHP

COMMUNITY PROFILE

CHRIS AVILES

From emotional video games to agricultural code clubs, one Raspberry Pi educator is a big fan of using technology to grow their students

Chris

Category: Educator
Day job: Edtech Coach
Website: techedupteacher.com
twitter.com/techedupteacher

SILAS GAMIFICATION

"Outside of class, I'm still working with tech," says Chris. "Another teacher in my school, Chris Dudick, and I built a video game called SiLAS to help students with their social emotional learning. We recently brought the game to market, so running that business takes up some free time. It is worth it, though, since we're seeing big results."

magpi.cc/OcdJOc

Chris Aviles is a recovering high school English teacher and Raspberry Pi Certified Educator. He blogs at **TechedUpTeacher.com** and uses technology to level the educational playing field – he loves gamifying the classroom.

"Teaching wasn't always my passion," Chris tells us. "Growing up, I wanted to be a space cowboy." After a little more growing, Chris discovered that space cowboy wasn't a viable career option, leaving him looking for an alternative occupation.

"When I got to college I started out as a Chemistry major," he reveals, "but didn't feel inspired. After some self-reflection I realised I wanted to be an English teacher."

Chris then fell into the technology side of teaching. "I just finished my Master's in Education Technology, but before that I had no formal technology training. My tech background was a combination of passion and inspiration from my father, who worked in IT in the military and then for AT&T for 25 years."

Over time, Chris has become a Google Certified Innovator, leader of Google Education Group New Jersey, was one of CTE's (Career and Technical Education) top 30 educators, and

Students use the weather station to help them grow crops, which they sell on an online store they code and run

GROWING CODERS

magpi.cc/UblkqR

"In FH Grows, seventh graders learn to be stewards of the environment while using technology to help our gardens grow," explains Chris. "The students sell herbs online and grow produce in our student-run farmers' market. When they're not working in the gardens, they are trying to solve the food problems of our future.

"A particularly fun part of class is using the Raspberry Pi to collect data on weather and their greenhouse from student-built sensors and our Raspberry Pi Oracle Weather Station. Using this data, students must make decisions about what to do for the plants with that information. If the data shows the greenhouse is too hot, they open the doors and turn on the fans. Too cold and they turn on the heaters. If the weather station shows the possibility of rain, they don't water."

This is their first year, and Chris hopes next year to compare weather data and determine best times to plan and harvest.

> "Growing up, I wanted to be a space cowboy..."

is an ISTE (International Society for Technology in Education) Emerging Leader for 2016.

Build to learn

It was playing with his dad that gave Chris a love of building. "He was always busy," recalls Chris, "so our bonding time was spent building computers and playing Nintendo when we could. Even back then, I loved to take things apart, see how they worked, and put them back together. Now, I teach my kids how to do the same thing."

It was while using Raspberry Pi in the classroom with a passionate group of students that he thought of getting involved with the community. "I wanted to get better at the Raspberry Pi so I could spread that passion further amongst my kids and colleagues," he explains.

These days, Chris works as the Edtech Coach for Fair Haven school district in Fair Haven, NJ. He spends half of his day working with teachers and the other half running Fair Haven's famous Innovation Lab and related Innovation Initiatives.

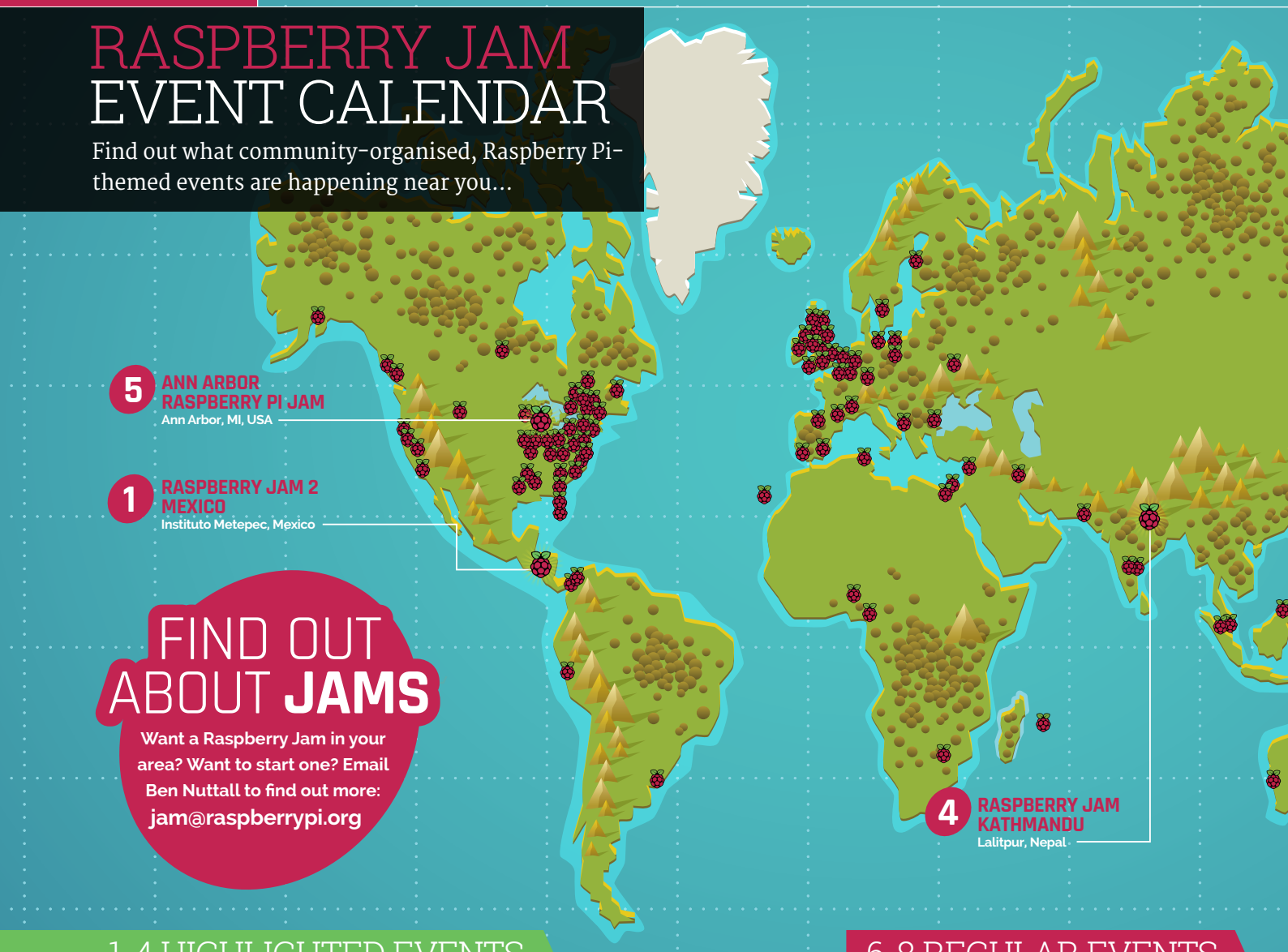
"Picademy seemed like a logical step. I applied for the first ever American Picademy, but didn't get in. Two years later, I applied for the Picademy in Rhode Island and was accepted. It was worth the wait."

He is a big fan of RetroPie, and recently built an automatic door for his dog. "I'll be leading the Picademy this summer in Seattle and hope to return to Maker Faire to share more about using the Raspberry Pi in the garden," he tells us.

Below Chris and students with the Raspberry Pi Oracle Weather Station

RASPBERRY JAM EVENT CALENDAR

Find out what community-organised, Raspberry Pi-themed events are happening near you...


5 ANN ARBOR RASPBERRY PI JAM
Ann Arbor, MI, USA
1 RASPBERRY JAM 2 MEXICO
Instituto Metepec, Mexico
4 RASPBERRY JAM KATHMANDU
Lalitpur, Nepal

FIND OUT ABOUT **JAMS**

Want a Raspberry Jam in your area? Want to start one? Email Ben Nuttall to find out more: **jam@raspberrypi.org**

1-4 HIGHLIGHTED EVENTS

1 RASPBERRY JAM 2 MEXICO

When: Saturday 9 June
Where: Instituto Metepec, Mexico, Mexico
magpi.cc/DLSrpO
Showing the capabilities of the Raspberry Pi to help develop computing skills.

2 BOGNOR REGIS RASPBERRY JAM

When: Saturday 9 June
Where: University of Chichester, Bognor Regis, UK
magpi.cc/nMAzkN
The postponed second Jam is finally taking place! Go along for inspiration on your next Pi project.

3 LONDON PI JAM

When: Saturday 9 June
Where: Microsoft Reactor, London, UK
magpi.cc/UDfPfK
There will be drop-in events and workshops, along with plenty of fun and raffle prizes.

4 RASPBERRY JAM KATHMANDU

When: Saturday 9 June
Where: Nepal College of Information Technology, Lalitpur, Nepal
magpi.cc/JjWGaf
Learning sessions and workshops, plus presentations about the Raspberry Pi.

6-8 REGULAR EVENTS

5 ANN ARBOR RASPBERRY PI JAM

When: Sunday 24 June
Where: Ann Arbor District Library Secret Lab, Ann Arbor, MI, USA
magpi.cc/fTsrBc
Meet local Pi users, check out some projects, and try out some coding for yourself!

6 PRESTON RASPBERRY JAM

When: Monday 4 June
Where: Media Factory Building, Preston, UK
magpi.cc/QNCuwb
A community who meet each month to learn, create, and share the potential of the Pi.

WE'VE HIGHLIGHTED SOME OF THE AREAS IN NEED OF A JAM! CAN YOU HELP OUT?

7 LEEDS RASPBERRY JAM

When: Wednesday 6 June
Where: Swallow Hill Community College, Leeds, UK
magpi.cc/ijNzhC
Get hands-on with digital making activities through the workshop, plus a hackspace area to share projects.

8 CORNWALL TECH JAM

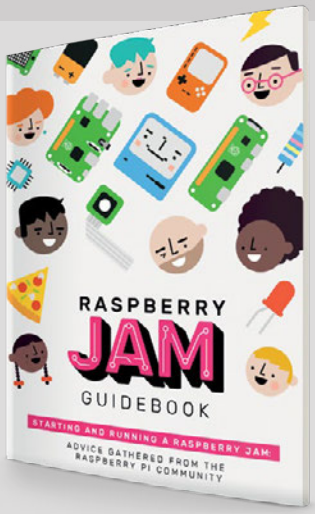
When: Saturday 9 June
Where: Cornwall College Pool, Redruth, UK
cornwalltechjam.uk
Learn about programming on a variety of platforms including Arduino and Raspberry Pi in various languages.

RASPBERRY JAM ADVICE

PLANNING YOUR SECOND EVENT

> "I know I'll need some good ideas to move beginners on, or they won't return. I know I will have to advertise more widely to get the same number of people next time. People always come in greater numbers to the first of something new."
>
> **Anne Carlill**
> **York Raspberry Jam**

Every Raspberry Jam is entitled to apply for a Jam starter kit, which includes magazine issues, printed worksheets, stickers, flyers, and more. Get the guidebook here: **magpi.cc/2q9DHfQ**



YOUR LETTERS

SHORTLINK PROBLEMS

I was looking through a recent issue and decided to look at the website that would give me a bit more info on the article. However, I realised I'm never sure what to do with the link in the article? It seems to be special code. Do I have to put it into somewhere on the Raspberry Pi?
Liam

The shortlinks in the magazine are just plain old website URLs – just put one in your browser address bar as it's shown and you'll be redirected to the website we're referencing. It just saves you having to type out a 100-character link!

If you're having some problems in your browser, try adding https:// before the rest of it. If all else fails, download the issue's PDF and go to the same page you're looking at in the magazine, then click on the link. They're all clickable in there and should take you to the relevant site.

ALL-AMERICAN SUBSCRIPTIONS

I've recently discovered your magazine and love the articles. However, I seem to be quite unlucky at getting the new copies when they turn up at my local Micro Center.

I understand that you're based in the UK, but do you offer a subscription to the United States at all? I'd love to support the magazine and the Foundation, as well as make sure I get myself a copy every month!
J. Mark

Absolutely! You can get a subscription to anywhere in the world and we even have a special version for US subscribers. The price includes shipping and you can get a rolling monthly subscription or splurge on the twelve-month sub that nets you a Pi Zero W and accessories bundle as well.

You can find our subscription offers by heading to **magpi.cc/subscribe** for more information.

GET A PI ZERO W WITH A SUBSCRIPTION! PAGE 26

BUYING BACK ISSUES

I've been reading *The MagPi* for years, and have been subscribing for most of that time as well. I have a nice collection of magazines to show for it as well!

I must admit though that when it came to resubscribing recently, I did it a bit late and missed out on issue 67. I didn't realise until I filed away my copy of 68 and noticed the numbers! I looked in a few of my local shops but I couldn't find a copy of 68, so I was wondering if there was a way to get issue 67 at all? Or is it too late?
Brian Lee

We do have a number of back issues available on our online store (**store.rpipress.cc**) and at the time of writing it looks like issue 67 with the retro computing cover is still in stock!

Unfortunately, we don't do any reprints unless there's a very special circumstance. So if an issue is listed as sold out, it will likely be gone forever. 66 is already sold out for example, so they can go quickly.

We'd also like to mention to readers that if they had an issue not turn up that should have been included with a subscription, please contact us and we'll try and sort out getting it resent.

In the worst-case scenario, when missing an issue that's unavailable, one solution is to take the free downloadable PDF to be printed by a specialist so you can at least have it on the shelf.

Missing a copy of *The MagPi*? You can grab one on our online Raspberry Pi Press store

FROM THE FORUM:

MORE ON 3D PRINTING

WRITE TO US

Have you got something you'd like to say?

Get in touch via **magpi@raspberrypi.org** or on The MagPi section of the forum at: **raspberrypi.org/forums**

The Raspberry Pi Forum is a hotbed of conversations and problem-solving for the community – join in via **raspberrypi.org/forums**

Great article [in issue 69] on getting into 3D printing and using the Raspberry Pi with OctoPrint! It does however gloss over some important details in getting OctoPrint up and running. If you need help, visit the OctoPrint website (octoprint.org); go to the downloads page to find the current OctoPi image, and scroll down for installation instructions, including a text description and video.

Visit the YouTube page (magpi.cc/kzBuzZ) for a very good series of OctoPrint Tutorial Videos by Joe Mike Terranella, including not just basic initial setup but a number of advanced topics.

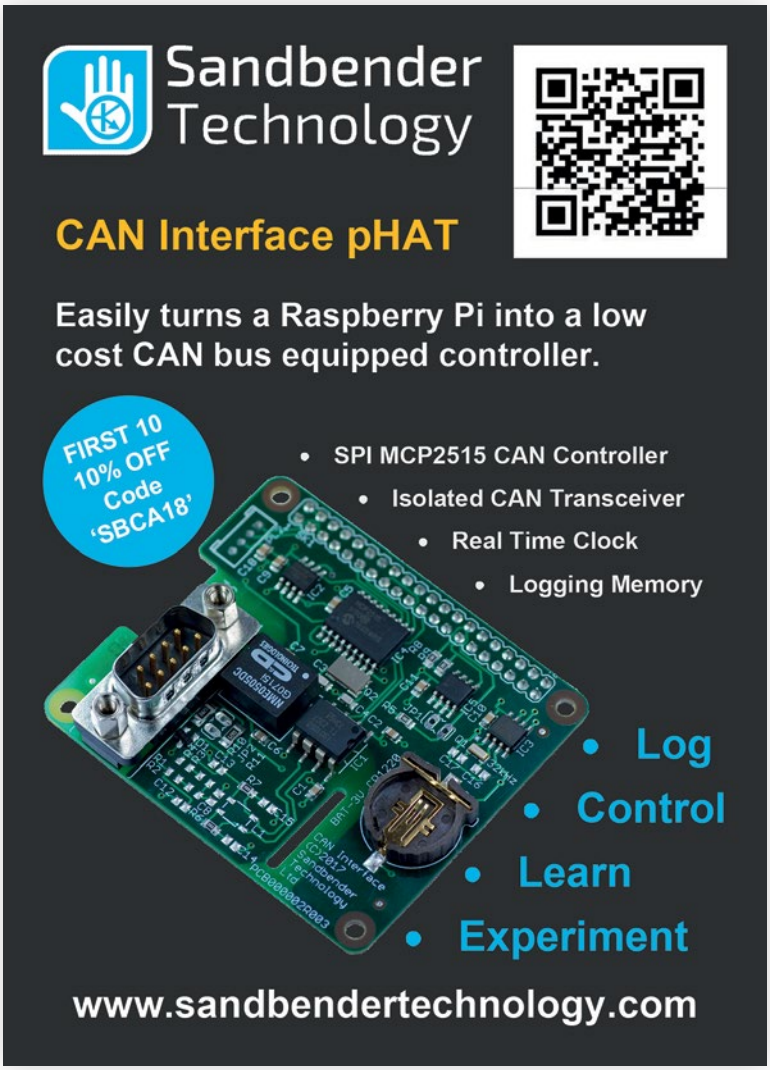
Since it seems to be a surprisingly common problem for people to get their WiFi connection up and running with OctoPi, here's a link to Getting Your WiFi Connection Working when using OctoPi/OctoPrint: magpi.cc/mvTfzY.

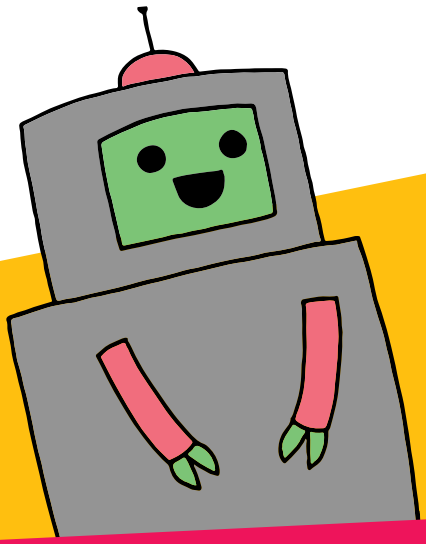
If you need further assistance, visit the official OctoPrint support website (magpi.cc/dyatrC). Check out the help and FAQ sections. Odds are if you are having a problem, someone has already worked through it.

There is also an OctoPrint Facebook group (magpi.cc/HWJJzu) which may be helpful.

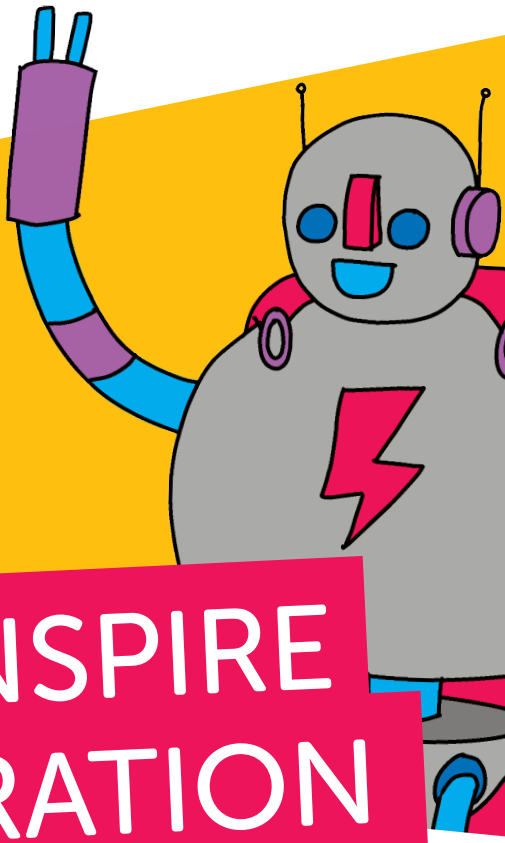
John Mc

Thanks John! Also, OctoPi has since been updated to work on the Raspberry Pi 3B+ (version 0.15).





{code club}

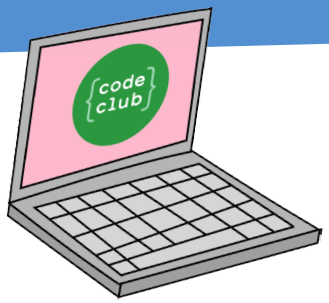


CAN YOU HELP INSPIRE THE NEXT GENERATION OF CODERS?

Code Club is a network of volunteers and educators who run free coding clubs for young people aged 9-13.

We're always looking for people with coding skills to volunteer to run a club at their local school, library, or community centre.

You can team up with friends or colleagues, you will be supported by someone from the venue, and we provide all the materials you'll need to help children get excited about digital making.



To find out more, join us at

www.codeclubworld.org

Code Club is part of the Raspberry Pi Foundation. Registered Charity Number 1129409

WIN!

In association with NANOSOUND

7 NANOSOUND DAC PRO & AMP KITS

We've got seven NanoSound DAC Pro & Amp kits up for grabs

There are a number of DAC (digital-to-analogue converter) devices available for the Raspberry Pi. These add-on boards enable you to hook up the humble machine into a professional sound system and play high-quality audio.

We reviewed the Nanomesher NanoSound DAC Pro in issue 65 (**magpi.cc/sobXjn**) and gave it five stars. We loved its on-board display and remote control.

The wonderful folks at Nanomesher have got seven of the NanoSound DAC Pro and Amp kits to give away. Enter today for a chance to win one...

Enter now at magpi.cc/win

Learn more: magpi.cc/ABUWzP

Terms & Conditions

Competition opens on **30 May 2018** and closes on **29 June 2018**. Prize is offered to participants worldwide aged 13 or over, except employees of the Raspberry Pi Foundation, the prize supplier, their families or friends. Winners will be notified by email no more than 30 days after the competition closes. By entering the competition, the winner consents to any publicity generated from the competition, in print and online. Participants agree to receive occasional newsletters from The MagPi magazine. We don't like spam: participants' details will remain strictly confidential and won't be shared with third parties. Prizes are non-negotiable and no cash alternative will be offered. Winners will be contacted by email to arrange delivery. Any winners who have not responded 60 days after the initial email is sent will have their prize revoked. This promotion is in no way sponsored, endorsed or administered by, or associated with, Instagram or Facebook.

MATT RICHARDSON

Matt Richardson is the Executive Director of the Raspberry Pi Foundation North America and author of *Getting Started with Raspberry Pi*. Contact him on Twitter @**MattRichardson**.

IOT FOR YOU AND ME

Matt Richardson explores a few maker-friendly tools for connected devices

Affordable hardware and advances in connectivity technology have helped launch the Internet of Things, a network of objects that communicate with each other over the internet. Luckily for hobbyists like us, IoT isn't just for big businesses. With well-documented and affordable off-the-shelf hardware like Raspberry Pi and free or affordable software platforms for collecting and passing data, there's a lot we can do without spending a lot. We have the ability to experiment with IoT and build our own custom home automation systems based on the protocols, platforms, and tools of the Internet of Things.

Raspberry Pi has always been a great hardware platform for IoT. Even the very first Raspberry Pi was affordable and had an Ethernet port to connect it to the internet. Since then, the Raspberry Pi product line has improved to become even better for IoT applications. Raspberry Pi Zero W provided wireless connectivity in a tiny package. And the recently released Raspberry Pi 3 Model B+ coupled with a PoE HAT makes the Raspberry Pi capable of Power over Ethernet, so that wherever you put the Raspberry Pi, you can power it and provide connectivity over a single Ethernet cable.

Support services

To support Raspberry Pi-based IoT projects, there have been recent developments by a lot of different companies and many of them provide a low-cost (or even free) hobbyist level of their services that will suffice for most of our needs. I want to share with you some of the cool IoT stuff which has caught my eye lately.

Just last month, Google opened up the beta of Android Things (**magpi.cc/WhzGcr**) to the public. Android Things allows you to use Raspberry Pi 3 to make smart connected devices based on the Android operating system and development tools. If you're looking to tinker or use it in your home, you can use it for up to 100 devices for free. This is a great option for making pretty cool devices, especially if you already know your way around the world of Android app development.

Mozilla provides a free platform for IoT called Project Things (**iot.mozilla.org**). In their words, it's an "experimental framework of software and services from Mozilla for connecting 'things' to the web." Their gateway software runs on the Raspberry Pi and helps you control connected devices from within your home or even remotely via the web. Their Things Framework allows you to create your own devices, define their functions, and make those functions discoverable on your network.

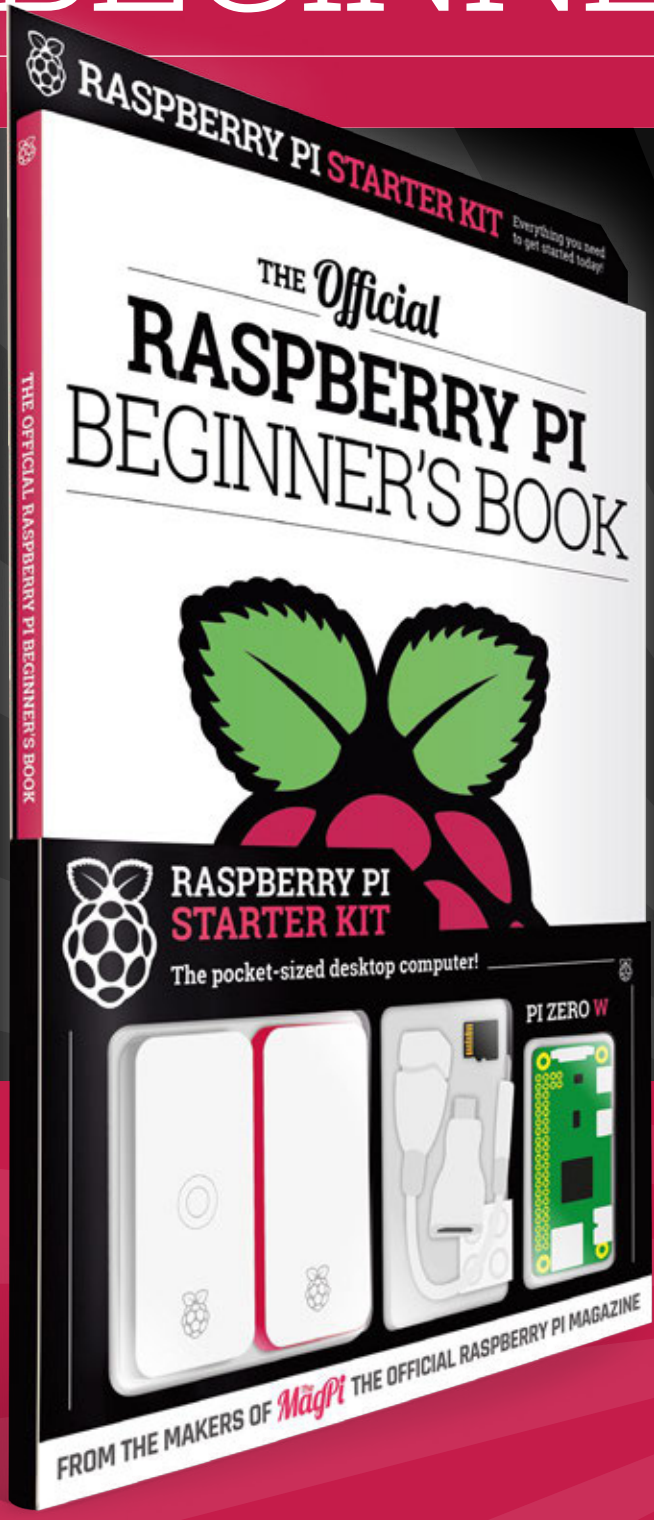
> "Raspberry Pi has always been a great hardware platform for IoT"

Remote connectivity

If you have a project that takes you away from your home network and you want to have connectivity where there's no WiFi, you can use a nice piece of hardware called Nova by the folks at Hologram (**hologram.io/nova**). Nova plugs into your Raspberry Pi's USB port and provides connectivity wherever there's a GSM cellular network. They've priced the data plans reasonably and their platform for managing the messages is quite slick. I've tried Nova out myself and clearly the product is geared towards big businesses with thousands of devices all over the world, but you can still get started quite easily at maker scale.

These are just a few highlights from the many different offerings out there. The affordability of the Raspberry Pi, coupled with these affordable and well-documented tools, means that hobbyists like us can experiment and solve problems in our world using industrial-grade tools without paying an industrial-grade price. It means that IoT is also for you and me.

THE *Official* RASPBERRY PI BEGINNER'S BOOK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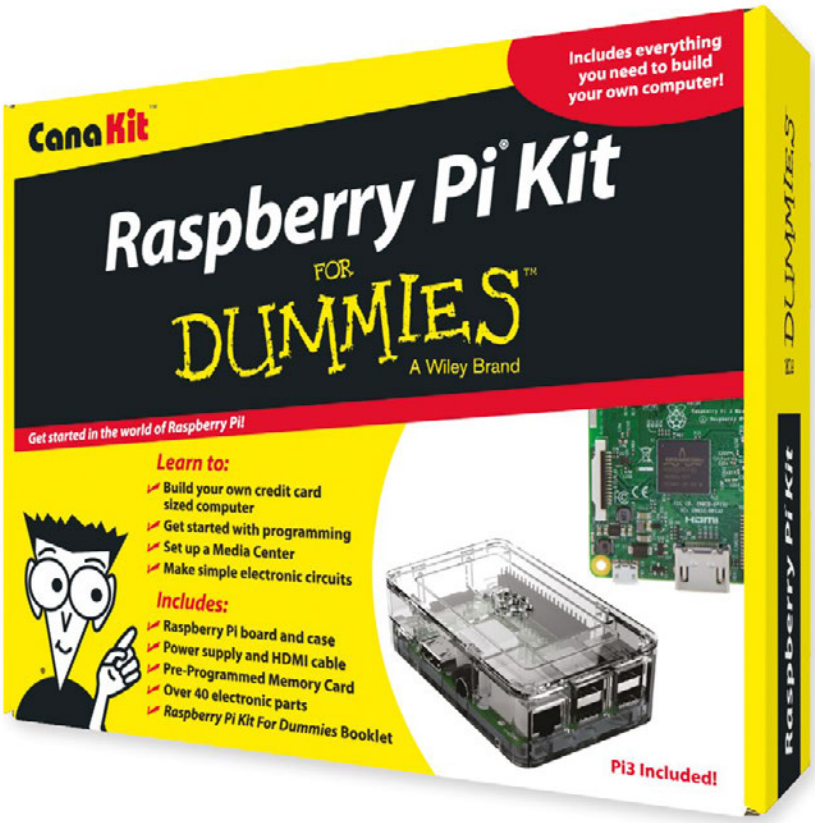

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